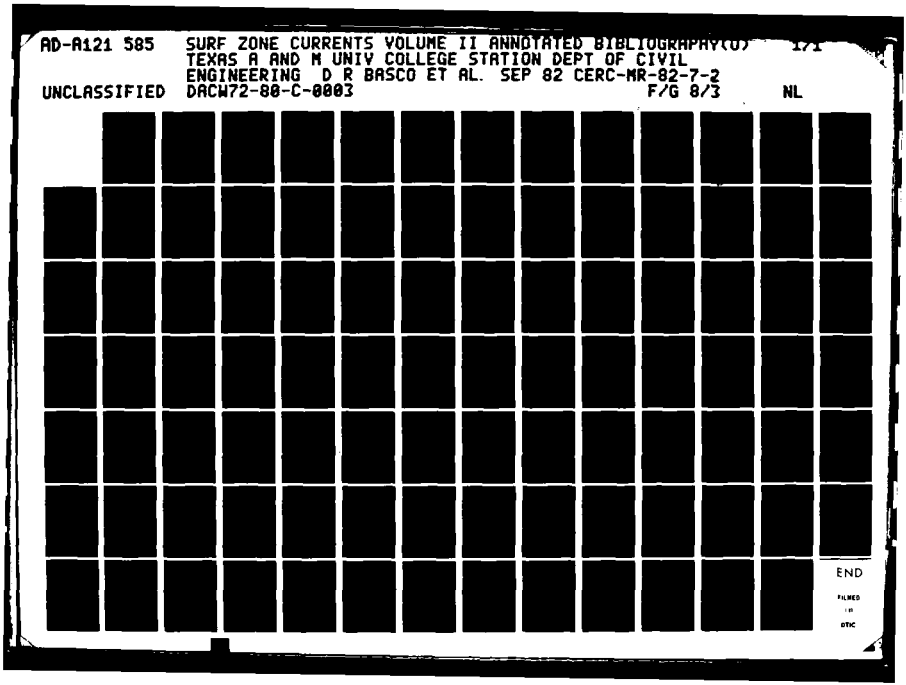
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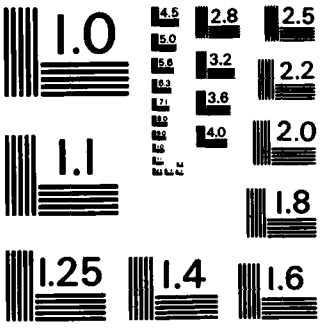

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Surf Zone Currents

VOLUME II

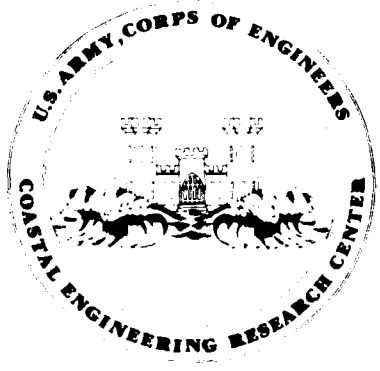
Annotated Bibliography

by

David R. Basco and Rod A. Coleman

MISCELLANEOUS REPORT NO. 82-7 (II)

SEPTEMBER 1982



Prepared for

U.S. ARMY, CORPS OF ENGINEERS
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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MR 82-7 (II)	2. GOVT ACCESSION NO. AD-A121585	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* SURF ZONE CURRENTS Volume II. Annotated Bibliography		5. TYPE OF REPORT & PERIOD COVERED Miscellaneous Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David R. Basco Rod A. Coleman		8. CONTRACT OR GRANT NUMBER(s) DACW72-80-C-0003
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Civil Engineering Texas A&M University College Station, Texas 77840		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS B31672
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army Coastal Engineering Research Center (CERRE-CO) Kingman Building, Fort Belvoir, Virginia 22060		12. REPORT DATE September 1982 13. NUMBER OF PAGES 93
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Annotated bibliography
Coastal hydrodynamics
Longshore current
Nearshore circulations
Numerical models
Rip currents
State-of-the-art
Surf zone currents

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report (Vol. II) and a companion report entitled, "State of Knowledge of Surf Zone Currents" (Vol. I) are part of a major new study of coastal currents initiated by the Coastal Engineering Research Center in 1979. The two reports provide a state-of-the-art summary of theories and experiments investigated since 1967. The articles of primary interest in this bibliography discuss analytical theories, laboratory and field experiments, and numerical

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simulations of nearshore and surf zone currents. Also included are related articles on measurement technology, instrumentation to conduct experiments, and the following subareas: wave thrust (radiation stress), wave setdown and setup, bed shear in oscillatory flow, edge waves, wave breaking, bore theory, and momentum and energy fluxes in the surf zone.

PREFACE

This report (Vol. II) and the accompanying "State of Knowledge of Zone Currents" (Vol. I) are published to provide a state-of-the-art summary of research on coastal hydrodynamics and its three main components: longshore currents, nearshore circulations, and rip currents. The two volumes concentrate on all theoretical aspects since 1967 but include physical descriptions and experimental data made much earlier. The work was carried out under the U.S. Army Coastal Engineering Research Center's (CERC) Nearshore Waves and Currents work unit, Harbor Entrances and Coastal Channels Program, Coastal Engineering Area of Civil Works Research and Development.

The report was compiled and annotated by Dr. David R. Basco, Associate Professor, Department of Civil Engineering, and Rod A. Coleman, Ocean Engineering Department, Texas A&M University, College Station, Texas, under CERC Contract No. DACW72-80-C-0003.

The authors gratefully acknowledge J. Hyden and S. Hall for their assistance in preparing the report, and the following individuals for their assistance in obtaining copies of the reports and journal articles cited: Prof. A.T. Barcilon, Florida State University; Prof. J.A. Battjes, Delft Technical University; Prof. A.J. Bowen, Dalhousie University, Nova Scotia; Prof. J. Chappell, University of Sydney; Prof. R.A. Dalrymple, University of Delaware; Dr. M.D. Earle, Naval Oceanographic Office; Prof. W.T. Fox, William's College; C. Gilreath, Texas A&M University Library; Dr. M.R. Gourlay, University of Queensland, Australia; J. van de Graaff, Delft Technical University; Dr. R.T. Guza, Scripps Institution of Oceanography; Prof. T.F.W. Harris, University of Auckland, New Zealand; Prof. K. Horikawa, University of Tokyo; Prof. D.L. Inman, Scripps Institute of Oceanography; Prof. I.G. Jonsson, Technical University of Denmark; Prof. J.W. Kamphuis, Queen's University, Ontario; Prof. P.D. Komar, Oregon State University; B.F. Maddox and staff, CERC Library; Dr. R.J. Seymour, California Department of Navigation and Ocean Development; Prof. R. Silvester, University of Western Australia; W.A.M. Smulders, Delft Hydraulic Laboratory Library; Tetra Tech, Inc., Pasadena, California; Prof. E.B. Thornton, Naval Postgraduate School, Monterey; Prof. J.D. Wang, University of Miami; and Dr. H.G. Wind, Delft Hydraulic Laboratory, DeVorrst. Those contributing whose names are not listed, hopefully, will not be offended by the oversight.

Dr. C.L. Vincent, Chief, Coastal Oceanography Branch, was the CERC contract monitor assisted by M. Mattie, under the general supervision of Mr. R.P. Savage, Chief, Research Division. The author wishes to acknowledge their assistance in providing useful references, technical review, and preparing the final manuscript.

Technical Director of CERC was Dr. Robert W. Whalin, P.E., upon publication of this report.

Comments on this report are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

A

CONTENTS

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

SURF ZONE CURRENTS
Volume II. Annotated Bibliography

by

David R. Basco and Rod A. Coleman

I. INTRODUCTION

Investigations of nearshore currents have primarily been motivated by the desire to understand sediment transport, erosion, and accretion processes and, in recent years, the transport and dispersion of pollutants. Those currents generated by short-period surface gravity waves in water depths generally less than 10 meters are particularly important. The major types include wave-driven longshore currents and nearshore circulation cells, along with rip currents, onshore-offshore flows caused by winds, and wind-induced alongshore flows.

The articles of primary interest in this bibliograhy discuss analytical theories, laboratory and field experiments, and numerical simulations of nearshore and surf zone currents. Also included are related articles on measurement technology, instrumentation to conduct experiments, and the following subareas: wave thrust (radiation stress), wave setdown and setup, bed shear in oscillatory flow, edge waves, wave breaking, bore theory, and momentum and energy fluxes in the surf zone. Since the literature in some of the subareas is extensive enough to warrant separate bibliographies, only some of the most important or recent articles are included. A few sediment transport articles are also included in cases where coastal hydrodynamics was investigated.

II. SOURCE INFORMATION

Each entry of the bibliography has a reference number, author or source information, keywords, and when possible, a summary of the content of the article. An alphabetical index of subject heading (keywords), indicating reference numbers of the sources is given as Appendix A. Most of the annotations are condensed versions of summaries provided by the authors of the articles or by Delft Hydraulic Laboratory (DHL), Dissertation Abstracts International (DAI), and Oceanic Abstracts (AM). The source, when used, is indicated in parentheses at the end of each summary. The complete bibliography was compiled from various sources, including computer-based indexes, library card indexes, and various journals, conference proceedings, etc. Appendix B provides a list of these sources.

III. ANNOTATED BIBLIOGRAPHY

1. ABBOTT, M.B., "New Development in Short Wave Computation," Part II, *The Dock and Harbour Authority*, Vol. 59, No. 692, July 1978, pp. 66-69.

Keywords: *Wave theory, Boussinesq equations, Intermediate short waves, Computer models, Harbor oscillations*

The Danish Hydraulic Institute has developed a version of their System 21, "Jupiter," computer for long wave flows which can solve equations that account for the vertical accelerations that determine the essential characteristics of short-wave flows--the "Mark 8" version. The following facilities are now available to harbor designers and authorities, terminal operators, and others concerned with short wave motions: models capable of synthesizing a short wave climate in a 50-meter water depth, using only readily available meteorological data; models capable of routing this wave climate into shallower water, and so into the vicinity of harbors, marine terminals, and other works; and models that describe the complete behavior of waves in a harbor caused by this wave climate. These last models, which automatically account for all refraction, diffraction, and reflection effects, introduce "radiation stresses" or "wave thrusts" and their corresponding longshore currents, and correctly introduce the partial transmissions and reflections effects of permeable constructions. The models can be run simultaneously with a simulation of a ship-mooring fendering system in which such empirical elements as "added mass" and "bottom effects" are eliminated. They can also be used with physically realistic irregular waves (as opposed to periodic wave functions) that are entirely compatible with those that must be used in detailed physical model investigations of ship-mooring fendering systems. (AM)

2. ABBOTT, M.B., PETERSEN, H.M., and SKOVGAARD, O., "Computations of Short Waves in Shallow Water," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978a, pp. 414-433.

Keywords: *Numerical models, Water waves, Longshore currents*

The simulation of short wave propagation, including refraction, diffraction, partial reflection and other such features, is made possible by a new version of the System 21, Jupiter. The system-generated models can describe any bathymetry and topography with any time-varying mean flow, correctly accounting for wave and current interactions, wave thrusts or radiation stresses, longshore currents, and other "second-order" effects. The models work with both regular and irregular waves. Radiation boundary modules are also provided to eliminate models dropped in any desired region and introduce new features without invalidating the field study determined boundary data. System-generated models can be constructed and run in a few hours, starting from charts, a layout of the proposed engineering works, and the available boundary data. The development and testing of the system is briefly described along with its applications in coastal engineering practice. (Authors)

3. ABBOTT, M.B., PETERSEN, H.M., and SKOVGAARD, O., "On Numerical Modeling of Short Waves in Shallow Water," *Journal of Hydraulic Research*, Vol. 16, No. 3, 1978b, pp. 173-204.

Keywords: *Wave theory, Quasi-long waves, Vertical acceleration, Numerical models*

A modeling system is described that generates and runs short wave models of any form (periodic or irregular), with any desired physically realistic current field over any given bathymetry. This system, which constitutes the eighth version of the general System 21, "Jupiter," is called the "Mark 8." The system-generated models are based on Boussinseq equations (where the vertical velocity increases linearly from zero at the bed to a maximum magnitude at the surface, in two independent (horizontal) space variables and time). The Boussinesq equations are formulated as mass and momentum conservation laws while, by virtue of the high order of accuracy of the difference approximations, there is very little numerical energy falsification. This formulation also appears to provide genuine weak solutions, for correctly simulating breaking waves, and thus assures the correct simulation of wave thrusts or radiation stresses, and associated longshore currents. The main capabilities of the system have been tested against one- and two-dimensional analytical results and also against physical model tests. In all cases, the agreement of the system results with the analytical and physical results is satisfactory. The system is already being applied in engineering practice. A discussion is presented of the system to ship-motion simulations, to sediment transport computations, and also to more efficient nearly horizontal flow computations. (Authors)

4. ALLENDER, J.H., et al., "Comparison of Model and Observed Nearshore Circulation," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 810-827.

Keywords: *Nearshore circulation, Numerical model, Field measurements, Lake Michigan*

Results from a two-dimensional numerical model for nearshore circulation induced by waves and wind are compared with observations made during two storms at a beach on Lake Michigan. Model input data include bathymetry, offshore wave characteristics, wind histories, and local water level changes; predicted locations of the breaker zone are in rough accord with those observed during the storms. The comparison data consist of wave and current observations across the surf zone, especially those acquired by using a towed, instrumented sled. The comparisons show that the model often predicts peak currents near the breaker zone quite well, but underestimates the decay of wave height and the strength of longshore currents across the surf zone; however, wave breaking on the bar-trough beach structure apparently is not well represented by the model. (Authors)

5. APPELL, G.F., "Current Meter Performance in a Near-Surface Simulated Environment," *Exposure Newsletter*, Vol. 5, No. 2, May 1977.

Keywords: *Instruments, Current meters, Calibration*

6. APPELL, G.F., "A Review of the Performance of an Acoustic Current Meter," *Proceedings of a Working Conference on Current Measurement*, National Oceanic and Atmospheric Administration and University of Delaware, Technical Report, DEL-SG-3-78, 1978, pp. 35-58.

Keywords: *Instruments, Current meters, Acoustic type*

The Test and Evaluation Laboratory of National Oceanic and Atmospheric Administration (NOAA), National Ocean Survey (NOS) recently completed a limited performance evaluation of three Neil Brown Instrument Systems acoustic current meters (NBIS ACM-1's) for the NOAA Data Buoy Office. Steady-flow calibrations were performed on the four cardinal measurement axes, as well as directivity response evaluations in both the horizontal and vertical planes. Calibrations were performed on the solid-state compass used for magnetic heading reference in the current meters. Environmental tests for vibration and temperature were conducted. The methods and procedures used in the evaluation are discussed, and the results are graphically displayed. (Author)

7. ARHAN, M., and GOURITEN, Y., "Relations entre les variations de pression au Fond et les courants particulaires dans la houle cotiere proche du deferlement (Relations Between Bottom Pressure Variations and the Flow of Particles in Waves in the Breaker Zone)," *Annales Hydrographiques*, Paris, France, Vol. 4, No. 743, Series 5, 1976, pp. 59-64.

Keywords: *Surf zone, Wave particle velocity, Field measurements*

In situ recordings of pressure near the bottom and particle velocity in shallow water reveal the nonlinear nature of the flow in the breaker zone. The different frequency domains linked to nearshore currents, wind waves, and turbulence are determined using correlations and coherences. A quasi-linear pressure-velocity relation exists in the wind wave frequency range. (DHL)

8. ARTHUR, R.S., "A Note on the Dynamics of Rip Currents," *Journal of Geophysical Research*, Vol. 67, No. 7, July 1962, pp. 2777-2779.

Keywords: *Rip currents, Wave theory*

A vorticity equation is applied to the flow of a rip current that transports water seaward through a surf zone. If a column of water stretches vertically as it moves into deeper water, the magnitude of the vorticity will increase along the streamline. An approximate solution indicates that the width of the current decreases as the depth increases. This action of the nonlinear inertial terms may help to explain the maintenance of a relatively narrow, concentrated pattern of streamlines observed in rips. (Author)

9. BAKKER, W.T., "Littoral Drift in the Surf Zone," *Studierapport* W.W.K. 70-16, Rijkswaterstaat, Department of Coastal Research, Den Haag, The Netherlands, 1970.

Keywords: *Sediment transport, Wave thrust comparisons, Longshore currents*

The report discusses sediment transport near coastal groins, including sediment transport by waves, some transport formulas, and mathematical modeling of coasts. A detailed comparison of the momentum conservation formulas for mean longshore currents by Eagleson (1965), Putnam, Munk, and Traylor (1949), and Longuet-Higgens (1970) is provided in an appendix.

10. BAKKER, W.T., "The Influence of Longshore Variation of the Wave Height on the Littoral Current," Studierappot W.W.K. 71-19, Rijkswaterstaat, Den Haag, The Netherlands, 1971.

Keywords: *Longshore current, Wave theory, Longshore wave height variation*

The experiments of Bowen (1969) showed that a difference in wave height along the shoreline causes differences in mean water level in the surf zone, i.e., a different setup. If the wave height changes in longshore direction, these differences in water level will cause a longshore gradient of the water surface which in turn causes a longshore current. This report is a *theoretical* review of this phenomenon.

11. BALSILLE, J.H., "Surf Observations and Longshore Current Prediction," TM-58, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Nov. 1975.

Keywords: *Longshore currents, Field studies, Dye tracers, LEO program*

Simultaneous field observations of breaker and current behavior were made using techniques of the Littoral Environmental Observation (LEO) program. The program, which was developed at CERC, is used to collect data on beach and surf conditions. The data base represents a concentrated data collection effort over a 1-year period at three beach sites at Point Mugu, California. Longshore current behavior is investigated in two ways: (a) observed, which is represented by the behavior of dye injected into the surf between the shoreline and breakers, and (b) predicted, which is based on the observation that longshore currents are generated primarily by waves. Predicted longshore currents are estimated using a relationship for the average longshore current across the surf. The prediction model relies on the consideration of the radiation stress or wave thrust on water inside the breakers, and is evaluated using LEO breaker heights, angles of wave approach at breaking, and estimated widths of the surf zone. (Author)

12. BARRICK, D.E., EVANS, M.W., and WEBER, B.L., "Ocean Surface Currents Mapped by Radar," (reprinted from *Science*), *Proceedings of a Working Conference on Current Measurement*, Technical Report OEL-SG-3-78, National Oceanic and Atmospheric Administration and University of Delaware, June 1978, pp. 59-68.

Keywords: *Measurement systems, Instrumentation, Radar, Surface currents*

A high-frequency radar remote-sensing system for measuring and mapping near-surface ocean currents in coastal waters has been analyzed and described. A transportable prototype version of the system was designed, constructed, and tested. With two units operating tens of kilometers apart, the currents were mapped in near real time at a 3- by 3-kilometer grid covering areas exceeding 2000 square kilometers, out to a distance of about 70 kilometers from the shore. (Authors)

13. BATTJES, J.A., "Set-Up Due to Irregular Waves," *Proceedings of the 13th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 3, 1972, pp. 1993-2004.

Keywords: *Wave setup, Wave theory, Laboratory experiments, Irregular waves*

Energy losses in breaking irregular waves are estimated on the assumption that a wave, while breaking, loses only that part of its height which would be in excess of the breaker height for the given wave period and mean local depth. This leads to expression for the magnitude of the radiation stresses as to function of the distance offshore. From this the variations in mean water level and the longshore current velocity are calculated with existing methods. Laboratory measurements of setup in two-dimensional irregular waves are described. The data appear to some extent to be internally inconsistent which may be due to enclosed air bubbles. (Author)

14. BATTJES, J.A., "Computation of Set-Up, Longshore Currents, Run-Up and Overtopping Due to Wind-Generated Waves," Report No. 74-2, Delft Technical University, Delft, The Netherlands, 1974a.

Keywords: *Longshore currents, Wave theory, Irregular waves, Wave setup, Laboratory experiments*

This report is primarily concerned with the calculation of effects resulting from random, irregular waves breaking on a slope. Due to nonlinearities, air entrainment, turbulence, etc., an empirical knowledge of mascroscopic breaker properties is necessary in these calculations. For mild slopes with spilling breakers the energy variation of waves propagating shoreward is computed by clipping a fictitious wave height distribution at an upper limit adapted from an empirical breaking criterion for regular waves. Results are said to be in fair agreement with measurements on plane slopes. The energy variation is used to evaluate the excess momentum

flux (radiation stress) which, in turn, is used for calculation of setup and longshore current velocity profiles on a plane, infinite beach. Examples of velocity profiles calculated show smooth forms through the surf zone and beyond. No lateral mixing terms are included in the computation, so the mixing is attributed to various breaker locations due to the random wave model used. The magnitude of the longshore current is shown sensitive to the width of the directional energy distribution in deep water. Wave setup of irregular laboratory waves was compared with the theory and found to be uniformly different. No plausible reason could be found to explain the discrepancy.

15. BATTJES, J.A., "Surf Similarity," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974b, pp. 466-480.

Keywords: *Surf zone, Wave theory, Wave breaking, Dimensionless parameters*

This paper deals with the following aspects of periodic water waves breaking on a plane slope: breaking criterion, breaker type, phase difference across the surf zone, breaker height-to-depth ratio, runup and setup, and reflection. These aspects are approximately governed by a single similarity parameter only, embodying both the effects of slope angle and incident wave steepness. Various physical interpretations of the similarity parameter are given, and its role is discussed in general terms from the model-prototype viewpoint. (Author)

16. BATTJES, J.A., "Modeling of Turbulence in the Surf Zone," *Proceedings, Symposium on Modeling Techniques*, American Society of Civil Engineers, Vol. 2, 1975, pp. 1050-1061.

Keywords: *Surf zone, Wave theory, Wave breaking*

This paper deals with the problem of estimating the horizontal turbulent momentum exchange in the surf zone. In contrast to previous models, the estimated relevant properties take into account the wave *energy* dissipation by breaking. The resultant expression for the turbulent energy dissipation, combined with an analysis of the interaction of the turbulent velocity field with the rate of strain in the longshore current, leads to estimates of the turbulence intensity, its macrolength scale, and its contribution to the momentum exchange. The latter appears in a form similar to that in the common eddy-viscosity models. (Author)

17. BATTJES, J.A., "A Critical Review of Conventional Models for Some Surf Zone Phenomena, with Special Reference to the Calculation of Nearshore Currents," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Surf zone, Theoretical models, State-of-the-art*

Concepts of radiation stress have provided a significant understanding of hydrodynamics of wave-driven currents in the surf zone. These concepts must be considered as first estimates due to the need to use relatively simple models for the wave-driving force, bottom shear stress, and lateral mixing. Author discusses the following seven areas where the state of knowledge is unsatisfactory:

(a) Lack of laboratory studies on flat slopes (10^{-2}) or with bar-trough profiles.
(b) The constant wave height-depth index in the surf zone which gives undue high sensitivity of longshore velocity to bottom profile variations.
(c) The variations of the breaker index (item b, above) for gentle slopes and bar-trough profiles.
(d) Lateral mixing of momentum treated uniformly both within and outside breaker zone even though turbulence is due to wave breaking.
(e) No turbulent mixing is observed outside breakers, yet theories predict a profile with tail.
(f) Bottom shear-stress formulations appear on an ad hoc basis.
(g) Extensions of the theory from regular to irregular waves are non-trivial.

18. BATTJES, J.A., and JANSSEN, J.P.F.M., "Energy Loss and Set-Up to Breaking of Random Waves," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 569-589.

Keywords: *Random wave breaking, Wave set-up*

A description is given of a model developed for the prediction of the dissipation of energy in random waves breaking on a beach. The dissipation rate per breaking wave is estimated from that in a bore of corresponding height, while the probability of occurrence of breaking waves is estimated on the basis of a wave height distribution with an upper cutoff which, in shallow water, is determined mainly by the local depth. A comparison with measurements of wave height decay and setup on a

plane beach and on a beach with a bar-trough profile indicates that the model is capable of predicting qualitatively and quantitatively all the main features of the data. (Authors)

19. BATTJES, J.A., and SAKAI, T., "Velocity Field in a Steady Breaker," *Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1980, pp. 1-13.

Keywords: *Wave velocities, Laboratory experiments, Instruments*

An experimental investigation is described of the velocity field in a steady spilling-type breaker, generated on a steady current by a submerged hydrofoil. Velocities were measured with a lasser-doppler system, and analyzed with respect to mean and root-mean-square values as well as Reynolds stresses. The results indicate that the turbulent flow field downstream of the initiation of the separation at the surface resembles that in a turbulent wake. (Authors)

20. BEARDSLEY, R., et al., "CMICE 76: A Current Meter Intercomparison Experiment Conducted Off Long Island in February-March 1976," *Proceedings of a Working Conference on Current Measurement*, Technical Report DEL-SG-3-78, National Oceanic and Atmospheric Administration and University of Delaware, June 1978, pp. 153-156.

Keywords: *Instruments, Current meters, Field tests*

A current meter intercomparison experiment (CMICE 76) was conducted about 6 kilometers off the southern coast of Long Island near 40°47'N., 72°30'W. during February and March 1976. A total of 20 current meters were deployed on six moorings set in a roughly linear array parallel to the local coastline and topography. The instruments included the Aanderaa RCM-4, the AMF VACM, the Brookhaven National Laboratory spar buoy system using cylindrical and spherical Marsh-McBirney electromagnetic sensors, the EG&G 650 and CT-3, and the Chesapeake Bay Institute-modified ENDECO 105. Local mean water depth was 27.8 meters and current meters were clustered near four depth levels (3.5, 7.4, 15.7, and 25.0 meters). Wave data were also obtained at the array site, and 10-meter wind and tidal data were obtained from nearby coastal stations. Intercomparison of 1-hour vector average velocities measured with similar instruments deployed near the same depth level indicated sufficient horizontal homogeneity that most differences in the observed current data have been attributed to real differences in instrument and mooring performance. Detailed discussions of the observed data, instrument and mooring characteristics and performance, and the effect of surface wave and wave-induced mooring motion on different measurement systems are presented. (Authors)

21. BETTESS, P., et al., "Longshore Currents Due to Surf Zone Barrier," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 776-790.

Keywords: *Nearshore circulations, Numerical models, Cooling water intakes*

The model results indicate that the patterns of wave-induced nearshore circulation can be predicted by numerical means. The main difficulties are the uncertainties in the values of bed friction and viscosity. Other problems include (a) the wave attenuation in the surf zone of the wave model, (b) the need for more reliable calculation of radiation stresses, including standing wave effects, and (c) the need for an improved model for turbulence.

Considered is a straight coastline exposed to large regular waves. The radiation stress gradients in the extensive surf zone cause setup and longshore currents; however, the beach is known to be fairly stable. If a cooling water intake basin is introduced on the coast, it must first be determined whether the wave-induced currents in the vicinity of the basin will affect the circulation of cooling water, and second, whether sediment transport will occur, leading to a dredging requirement for the basin. Physical model testing and numerical studies are being conducted to answer these questions. (DHL)

22. BIJKER, E.W., "The Increase of Bed Shear in a Current Due to a Wave Motion," *Proceedings of the 10th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1966, pp. 746-765.

Keywords: *Longshore currents, Boundary shear stress, Wave-current interaction*

As early as 1948 Einstein suggested that the approach to the calculation of sand transport by waves could be similar to that for uniform flow. Tests were conducted to prove that for a current with waves propagated in a direction perpendicular or almost perpendicular to the current, sand transport is a function of the intensity of bed shear in the direction of the current.

This paper presents the results of a study to determine the increase

of the bed shear of a current due to wave motion. Because it was not feasible to measure the bed shear directly, bed shear was determined indirectly by means of the energy slope. (Author)

23. BIRKEMEIER, W.A., and DALRYMPLE, R.A., "Nearshore Water Circulation Induced by Wind and Waves," *Symposium on Modeling Techniques*, American Society of Civil Engineers, Vol. 2, 1975, pp. 1062-1081.

Keywords: *Nearshore circulation, Wave theory, Numerical methods*

A finite-difference model for time-dependent, wave-induced nearshore circulation was developed which includes wave refraction, wave-current interaction, wave setup in wave tanks due to steady waves and wave groups, and also for a longshore periodic beach. Important results are that tuned wave groups can incite seiching in enclosed basins and harbors and that rip currents will be induced or maintained by the presence of surf zone channels. (Authors)

24. BIRKEMEIER, W.A., and DALRYMPLE, R.A., "Numerical Models for the Prediction of Wave Set-Up and Nearshore Circulation," Ocean Engineering Report No. 3, University of Delaware, Newark, Del., Jan. 1976.

Keywords: *Nearshore circulation, Theory, Numerical methods*

Report discusses the development of an explicit finite-difference model for predicting wave-induced nearshore circulation. The formulation includes wave refraction, wave-current interactions, quadratic bottom friction, wave setup, wind setup, wind effects, and coastal flooding. Three example cases are discussed: wave setup in a one-dimensional channel due to steady waves and groups; circulation due to oblique wave attack in a rectangular basin; and circulation on a longshore beach profile with periodic bathymetry.

25. BIVINS, L.E., and APPELL, G.F., "Turbulence Effects on Current Measuring Transducers," *Exposure Newsletter*, Vol. 3, No. 6, Jan. 1976.

Keywords: *Instruments, Current meters, Calibration*

26. BOCCOTTI, P., "On the Interactions Between Littoral Drift and Marine Structures," *Proceedings of the XVII IAHR Congress*, Vol. 4, 1979, pp. 139-142.

Keywords: *Nearshore circulations, Longshore currents, Wave theory, Numerical methods*

Paper discusses a method developed for calculating wave-driven currents under general boundary conditions and particularly in the presence of marine structures. The boundary condition selected was a jetty attached by a wave front angled with respect to the coastline. (DHL)

27. BOUWMEESTER, R.J.B., "Longshore Current Measurements: Gdansk Poland," Technical Report, Coastal Engineering Group, Delft Technical University, Delft, Netherlands, Jan. 1972.

Keywords: *Longshore currents, Field measurements, Poland*

A limited number of physical measurements of currents in surf zone were made using Rhodamine B dye. An analysis of the results was limited.

28. BOWEN, A.J., "Rip Currents," Ph.D. Dissertation, University of California, San Diego, Calif., 1967.

Keywords: *Rip currents, Theoretical model, Radiation stress, Laboratory study*

The generation of nearshore circulation patterns and rip currents by a wave train normally incident to the beach was investigated both analytically and in the laboratory. Concepts of radiation stress are employed to account for the excessive wave thrust. Circulation patterns are attributed to a longshore variation of radiation stress, hence they are directly related to the longshore variation in breaker height. Rips occur where the breaker height is low. Wave refraction, diffraction, bottom topography, or edge waves can all be mechanisms producing longshore wave height variations. A parameter is presented to give a useful estimate of the important edge wave modes.

29. BOWEN, A.J., "The Generation of Longshore Currents on a Plane Beach," *Journal of Marine Research*, Vol. 27, No. 2, Jan. 1969a, pp. 206-215.

Keywords: *Nearshore circulation, Theoretical model, Radiation stress*

The generation of longshore currents on a beach is investigated theoretically, using the concept of radiation stress to describe the flux of momentum associated with the incoming waves. Outside the surf zone, the longshore gradient of the radiation stress is always zero;

therefore, the flow is driven only inside the surf zone. The exact form of the longshore current is dependent on assumptions about both the behavior of the waves in the surf zone and the form of the viscous forces. However, with reasonable assumptions, the theory leads to a complete description of the velocity field as a function of the distance from the shore. The model provides a mathematical framework for testing the various possible assumptions by comparing them with reliable experimental data. One of Galvin and Eagleson's (1965) laboratory experiments is used to show the relevance of this approach. (Author)

30. BOWEN, A.J., "Rip Currents I. Theoretical Investigations," *Journal of Geophysical Research*, Vol. 74, No. 23, Oct. 1969b, pp. 5467-5478.

Keywords: *Nearshore circulation, Theoretical model, Radiation stresses*

The nearshore circulation of water on a plane beach produced by a wave train, normally incident on the beach, which has a longshore variation in wave height is theoretically investigated. The radiation stress arising from the excess flux of momentum due to the presence of the waves is found to provide driving terms for a steady-flow pattern only inside the surf zone. A circulation pattern is thus produced by a longshore variation in the radiation stress in the surf zone. In shallow water, the radiation stress is proportional to the square of the wave height. The nearshore circulation is, therefore, directly related to longshore variation in breaker height, currents flowing seaward where breaker height is low. When the inertial terms are included in the vorticity equation, an increase in the effective Reynolds number produces a narrowing, and consequently a strengthening of the seaward flow, which suggests an explanation for the existence of the strong, narrow currents known as rip currents. (Author)

31. BOWEN, A.J., "Wave-Wave Interactions Near the Shore, in, Waves on Water of Variable Depth," *Proceedings of the Symposium of the Australian Academy of Sciences*, Canberra, Australia, 1977, p. 102.

Keywords: *Wave theory*

Wave-wave interaction on a beach may be regarded as a rather special example of second order, resonant interaction within a rapidly changing wave spectrum. However, the existence of trapped modes, edge waves, with a different dispersion relation from that of the incoming waves provides the possibility of efficiently transferring energy to much lower frequencies than are normally observed in open sea. Any detailed analysis of these interactions is, however, greatly complicated by the *breaking* of the incoming waves as they reach water depths of the order of the wave height.

Recent field and laboratory data suggest that although the wave breaking introduces new effects, e.g., nearshore currents and setup forcing of the purely wave-wave interaction is not greatly altered by the breaking process. However, the increased effective viscosity of the region associated with the turbulent surf zone seems to play a significant role in suppressing resonance. Given equal forcing, edge waves with offshore wavelength scales that are large compared to the surf zone are more likely to exist. (Author)

32. BOWEN, A.J., and GUZA, R.T., "Edge Waves and Surf Beat," *Journal of Geophysical Research*, Vol. 83, No. 12, Apr. 1978, pp. 1913-1920.

Keywords: *Edge waves, Laboratory study, Resonance*

Surf beat, which is wave motion at relatively low frequency (periods of 30 to 200 seconds), is often observed on beaches. However, even with modern instrumentation it is difficult to describe the spatial variation of the low-frequency motion; consequently, the relative importance of a number of suggestions which, at least in theory, provide mechanisms for the generation of low-frequency energy has never been established. Recent observations have reinforced the idea that edge waves, the free wave modes trapped at the shoreline, are a major component of low-frequency energy. One of the most interesting explanations of surf beat suggests that the beating between particular pairs of incoming waves leads to resonant growth of edge waves modes, which may then dominate the low-frequency spectrum. Empirical evidence is essential, as any theoretical development breaks down when the incoming waves break, a fundamental problem with Gallagher's (1971) model. To investigate the importance of this resonant interaction, the general interaction conditions were therefore used to design laboratory experiments in which both resonant and nonresonant conditions were expected. The experimental results show that the response at the beat frequency is stronger when the resonance conditions for edge wave growth are satisfied and that the response is in the form of the theoretically predicted edge wave mode, even when the incident waves are breaking. These results strongly suggest that surf beat is predominantly an edge wave phenomenon. (Authors)

33. BOWEN, A.J., and INMAN, D.L., "Rip Currents 2. Laboratory and Field Observations," *Journal of Geophysical Research*, Vol. 74, No. 23, Oct. 1969, pp. 5479-5490.

Keywords: *Nearshore circulation, Rip currents, Theoretical model, Radiation stresses, Laboratory and field measurements*

The nearshore circulation of water on a plane beach exposed to a uniform wave train, normally incident on the beach, was investigated experimentally in the laboratory. The incident waves generated standing edge waves on the beach of the same frequency as the incoming waves. The interaction between these edge waves and the incident waves gave rise to steady-flow patterns (nearshore circulation cells) consisting of an onshore flow toward the breakers, a longshore current in the surf zone, and an offshore flow in relatively strong, narrow rip currents. The rip currents were found to occur at alternate antinodes of the edge waves, and the spacing of the rip current was therefore equal to the longshore wavelength of the edge waves. Although the incoming wave may interact with all the possible edge wave modes of the same frequency, it was found that the interaction with one particular mode is often dominant. A useful estimate of the relative importance of the modes is given. Field observations made in the Gulf of California strongly suggest that this mechanism is important on real beaches. (Authors)

34. BOWEN, A.J., and INMAN, D.L., "Nearshore Mixing Due to Waves and Wave-Induced Currents," Collected Reprint No. 957, National Institute of Oceanography, Dalhousie University, Nova Scotia, Canada, Dec. 1974 (*International Council for the Exploration of the Sea (ICES)*, Vol. 167, Dec. 1974, pp. 6-12).

Keywords: *Nearshore circulation, Wave theory, Lateral turbulent mixing*

Theories are reviewed for nearshore mixing due to surface waves for three mechanisms: (a) outside the breaker zone, (b) in the surf zone, and (c) that due to circulation cells, called longshore mixing. An excellent review of laboratory and field studies, plus theory for surf zone mixing, is given. Mixing here is limited by surf zone width and the data are limited, giving only order of magnitude estimates. Authors believe surf zone mixing reasonably approximated using Longuet-Higgins model with N=0.30.

35. BOWEN, A.J., INMAN, D.L., and SIMMONS, V.P., "Wave Setdown and Set-up," *Journal of Geophysical Research*, Vol. 73, No. 8, Apr. 1968, pp. 2569-2577.

Keywords: *Wave thrust, Laboratory study*

The negative and positive changes in mean water level due to the presence of a train of surface waves, setdown and setup, were measured in a wave channel. Well outside the breakpoint the experimental results are in good agreement with the theoretical relationship determined by Longuet-Higgins and Stewart. Near the breakpoint, where the wave height is greater than predicted by first-order wave theory, the measured setdown was consistently less than theory would predict from the deepwater wave height. Inside the breakpoint the bore height was found to be a linear function of the mean water depth. In this region, the gradient of the setup $d\bar{\eta}/dx$, was related to the beach slope tan β and the mean ratio of wave height to water depth $\bar{\gamma}$ by the equation $d\eta/dx = -[1 + (8/3\bar{\gamma}^2)]^{-1}\tan\beta$. (Authors)

36. BRADSHAW, M.P., "Topographic Control of Beach Run-Up Variability," *Abstracts, Proceedings of the 17th Conference on Coastal Engineering*, American Society of Civil Engineers, 1980, p. 442.

Keywords: *Nearshore circulations, Wave theory, Beach classification, Runup*

The beach classification system of Wright, et al. (1978) is used to study wave runup variability. Swash zone spectra are measured in the field and their variability over time is discussed.

37. BRADSHAW, M.P., et al., "Field Monitoring Analysis of Beach and Nearshore Hydrodynamics," Managing the Coast, *Fourth Australian Conference on Coastal and Ocean Engineering*, Barton Institute of Engineering, Canberra, Australia, 1978, pp. 171-175.

Keywords: *Measurement technology, Instrumentation*

An instrumentation system employing pressure-sensitive transducers bidirectional flowmeters, and a mobile minicomputer and data logger has been developed for high-resolution monitoring of wave and current activity in the nearshore zone. Transducers are used to measure incident wave characteristics, rate of energy dissipation, radiation stress gradients, and low-frequency oscillations of surf zone water level.

Low threshold, low inertia miniature flowmeters are used to observe nearshore circulation patterns, oscillatory bed velocities, and swash-backwash velocities. (DHL)

38. BREBNER, A., and KAMPHUIS, J.W., "Model Tests on the Relationship between Deep-Water Wave Characteristics and Longshore Current," Research Report No. 13, Civil Engineering Department, Queen's University, Kingston, Ontario, Aug. 1963.

Keywords: *Longshore currents, Laboratory study, Empirical theory*

A relationship is established, from model tests, between deepwater wave characteristics, namely, wave height, period and direction (these characteristics normally being obtained in the field from forecasting methods for given wind velocities and fetches, etc.), and the resultant longshore current setup on a uniformly sloping beach which is straight in plan.

The best relationships are found to be semiempirical since the theoretical approach is apparently beset by many doubtful assumptions regarding boundary conditions. (Authors)

39. BREBNER, A., and KAMPHUIS, J.W., "Model Tests on the Relationship Between Deep-Water Wave Characteristics and Longshore Currents," *Proceedings of the Ninth Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1964, pp. 191-196.

Keywords: *Longshore currents, Laboratory studies*

It has long been recognized that the movement of littoral material takes place, in the main, in the onshore regions of a beach where the breaking of waves occurs. Waves whose crests in deep water make an angle α_o with the shoreline, and which break at an angle α_B, are the main source of energy for the generation of the forces which manifest themselves in longshore currents and the resulting littoral transport. This littoral material is put into motion before, during, and after breaking but it is extremely difficult to separate the effects of the forces and currents in these three zones. In what follows the authors have attempted to measure the intensity of the current around the breaking zone in a highly idealized beach model in which the shoreline is straight, has a constant beach slope, θ, and is attacked by waves of constant deepwater waveheight, H_o and period, T.

During refraction and shoaling the angle of the wave crests with the shoreline is reduced from α_o to α_B and during this process some of the deepwater energy being transmitted shoreward may be dissipated by friction. The exact value of α_B is a function of α_o, H_o/L_o, and the friction loss, but will increase both theoretically and experimentally, with increasing H_o/L_o, as shown by Brebner and Kamphuis (1963).

Using energy consideration, $V_L = K_1[\theta \cdot \frac{H_B^2}{T} \cdot \sin 2\alpha_B]^{1/3}$ and momentum considerations $V_1 = K_2[\theta \cdot \frac{H_B^2}{T} \cdot \sin 2\alpha_B]^{1/2}$ where K_1 and K_2 are empirical "constants" depending on the friction energy offered to the longshore current, the amount of energy dissipated in the breaking process, and the amount used in maintaining onshore-offshore motion at right angles to the longshore current. (Authors)

40. BRENNINKMEYER, B.M., JAMES, C.P., and WOOD, L.J., "Bore-Bore Interaction on the Foreshore," *Symposium on Coastal Sediments '77*, American Society of Civil Engineers, 1977, pp. 622-638.

Keywords: *Surf zone, Field data, Velocities, Three-dimensional flow fields*

Two, bidirectional, electromagnetic current meters were used in the surf at Salisbury, Massachusetts to measure the velocity distribution within bores. The top meter was 15 centimeters vertically along a bottom meter within 10 centimeters of the bed. Depths varied, due to tides, so this single vertical array was located in the swash zone and outside the breaker zone during each tidal cycle. The measurements show that water motion in the various dynamic zones in the nearshore region changes radically. Within one breaker period, there are many onshore-offshore, longshore and vertical oscillations. Two distinct types of water motion in the surf zone are delineated: a primary motion which consists of bore-bore and bore-backwash interactions, and the secondary motion, which is formed by vortices, helixes, and boils within each bore. Helixes, the streaks of foam on the seaward side of a bore, are believed to be due to different penetration depths of uneven waves.

41. BRENNINKMEYER, S.J.B., "Three-Dimensional Water Velocity Pulsations Within the Surf Zone," *Euromech 102* (Breaking Waves: Surf and Run-up on Beaches) University of Bristol, Bristol, England, July 1978.

Keywords: *Longshore currents, Field measurements, Orbital particle velocities*

Measurements of water velocity within the surf zone on four beaches in New England and New York with an array of bidirectional electromagnetic current meters show that water pulsates frequently within each incoming bore. This is true for all three orthogonal axes which act in unison. As the bore passes a point there are strong onshore, down and longshore velocity components. This is immediately followed by offshore, upward and the other longshore direction pulses. (DHL)

42. BREVIK, I., "Remarks on Set Down for Wave Groups and Wave-Current Systems," *Coastal Engineering*, Vol. 2, No. 4, May 1979, pp. 313-326.

Keywords: *Wave setdown, Wave theory, Mechanisms*

Supplementary remarks are made on the change in the mean water surface (setdown) in some physical situations. Setdown may occur when the physical system is inhomogeneous in some way, for instance represented by the finiteness of a wave train, by the existence of a steady nonuniform current interacting with initially uniform waves, or by a gradually varying water depth. Considered in some detail are the two first of these cases, especially their similarities and differences. Also, in the case of a wave group, emphasis is placed on demonstrating the close relationship that exists between the underlying assumptions and the expressions obtained for velocity potentials and surface elevations. (DHL)

43. BRUNO, R.O., "Longshore Current System Panama City to Pensacola, Florida," M.S. Thesis, Florida State University, Tallahassee, Fla., 1971.

Keywords: *Longshore current, Empirical equations*

One year's data from six beach observation stations between Panama City and Pensacola, Florida, were analyzed to generate an empirical predicting equation for longshore current using stepwise multiple regression. Data from one of these stations were also used to test the radiation stress theory proposed by Longuet-Higgins; the test was inconclusive.

The empirical relation $V = -0.20 - 0.03(\alpha_b) - 0.02(W) + 0.031\ m) + E$ accounts for 48 percent of the variability of measured longshore currents and is similar to equations generated from data collected on the Atlantic seaboard. Wind roses, surf histograms, and average current conditions are presented for each observation site. Offshore and nearshore currents are discussed, and it is shown that the longshore current system is a result of wave-generated currents and an additive translatory motion. (Author)

44. BRUUN, P., "Longshore Currents in One and Multi-Bar Profiles Relation to Littoral Drift," *Proceedings of the Eighth Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1962, pp. 211-247.

Keywords: *Longshore current theories, Mass conservation, Laboratory and field studies*

This paper deals with longshore current theories. Introductorily, it gives a brief review of wave theories for breaking waves including theoretical, laboratory as well as field results. Next the longshore current theory based on momentum inflow over a uniformly sloping beach and bottom (Putnam, Munk, and Traylor, 1949) is discussed with special reference to its friction factor. The following chapters deal with two new longshore current theories, both based on the continuity principle. One of them called the rip current approach assumes that all water thrown in by wave breaking runs out in rip currents and will probably be valid for profiles with well-developed bars and waves approaching the shore almost perpendicularly. The other theory considers the fact that water from a wave breaking under an angle with the bar flows in with a certain phase difference in time longshore and this will create a longshore slope of the average water table, therefore also a longshore current. The water may return to sea uniformly as undertow or in rip currents or by a combination of both. This theory is particularly valid for waves breaking under a certain, not too small, angle with the bar. In both cases the momentum in the breaking waves is ignored because field observations show that in a well-developed bar profile most of the momentum has disappeared inside the bar after wave breaking. (Author)

45. BRUUN, P., "Longshore Currents and Longshore Troughs," *Journal of Geophysical Research*, Vol. 68, No. 4, Feb. 1963, pp. 1065-1078.

Keywords: *Longshore current theories, Mass conservation, Laboratory and field studies*

This paper deals with the longshore current theories discussed in the previous reference. It gives a brief review of breaking waves

including theoretical, laboratory, and field results, and discusses two new longshore current theories, both based on the continuity principle.

46. BUSCHING, F., "Ueber die Aenderung von Wellen-Perioden im Brandungsbereich," Mitteilungen Leichtweiss-Institute Wasserbau, Technical University of Braunschweig, No. 47, 1975, pp. 123-164.

Keywords: *Surf zone, Wave heights, Field studies, Spectral analysis, Germany*

Paper discusses the variation of wave periods in the surf zone, based on measurements of synchronous water level deflections at some positions in a beach profile with a slope of 1:40. Surf conditions were studied during severe storm surge as well as wave attenuation conditions. By using Fourier analysis, 40 energy spectra were calculated and presented in integrated form. Tidal influence was also analyzed. (DHL)

47. BUSCHING, F., "Energy Spectra of Irregular Surf Waves," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 539-559.

Keywords: *Surf zone, Wave heights, Field studies, Spectral analysis, Germany*

The investigations under consideration are based on synchronous measurements of water level deflections n(t) at some positions in a beach profile with a slope of approximately 1:40. Surf conditions are studied during a severe storm surge as well as during periods of attenuating wave action. By the use of a FOURIER ANALYZER 40 energy spectra are calculated and presented in integrated form (cocumulative spectra). Because of different site arrangements, the deformation of the spectra due to coastward-decreasing water depth was analyzed. (DHL)

48. BUSCHING, F., "Anomalous Dispersion of Fourier Components of Surface Gravity Waves in the Near Shore Area," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 247-267.

Keywords: *Surf zone, Wave heights, Field studies, Spectral analysis, Germany*

Water level deflections (η)(t) have been measured synchronously at some positions in a beach profile on the isle of Sylt, North Sea, during severe storm surge conditions as well as attenuating wave action. A steadily increasing wave period (mean T)(z) in the upbeach direction, turning out from strip-chart evaluations, is in accordance with the result of Fourier syntheses. Nearshore wave deformation is explained by anomalous dispersion of the frequency components. (Author)

49. CARTER, T.C., LIU, P.L-F., and MEI, C.C., "Mass Transport by Waves and Offshore Sand Bedforms," *Journal of the Waterways, Harbors and Coastal Engineering Division*, Vol. 99, No. WW2, May 1973, pp. 165-184.

Keywords: *Wave theory, Mass transport, Sediment*

Mass transport inside the oscillatory bottom layer near the sea bottom is studied for three-dimensional wave motion. Influence on the transport of fine and coarse sand and significance to the sea bottom morphology are presented. (Authors)

50. CHAPPELL, J., and ELIOT, I.G., "Surf-Beach Dynamics in Time and Space - An Australian Case Study, and Elements of a Predictive Model," *Marine Geology*, Amsterdam, Netherlands, Vol. 32, 1979, pp. 231-250.

Keywords: *Nearshore circulation, Field experiments, Coastal geomorphology, Surf zone energy model*

Inshore morphology and circulation on a medium- to high-energy surf beach in Durras, N.S.W., Australia, are analyzed from a semicontinuous run of data maps covering a 2.25-kilometer length of beach monitored at 50-meter intervals. Twenty surveys were made over about 5 weeks, the only significant gap being an interval of 12 days between the 13th and 14th records. Nearshore waves and winds varied considerably during the observation period; inshore morphology was highly changeable and longshore and rip circulation rarely was well fitted to morphology. From statistical analysis of morphologic and circulation patterns, a set of seven inshore states, were identified, related not only to immediate wave climate but also to antecedent morphology and wave changes. The problem was addressed of adjustment to energy changes, for the two-dimensional inshore-nearshore profile, using a model in which wave action on the bed is uniformly distributed. Model profiles fit closely to bathymetric data, and appear to predict reasonably the surf zone width variations resulting from energy changes. (Authors)

51. CHAPPELL, J., and WRIGHT, L.O., "Surf Zone Resonance and Coupled Morphology," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1978, pp. 1359-1377.

Keywords: *Nearshore circulation, Wave theory, Edge waves, Field studies, Australia*

The edge wave hypothesis for periodic inshore morphology and circulation is tested for five beaches and is supported by resulting wave-current spectral and cross-spectral data. Beach types range from a reflective, narrow surf zone, case to various dissipative medium to high-energy beaches including some with inshore bar-trough morphology and one broad surf zone troughless one. In all cases beach-face reflectivity is moderately high (E<2.5) and inshore resonance occurs, indicated by strong spectral peaks at lower than incident frequency with wave-current copeaks being 90° out of phase. Several different edge wave frequency and mode combinations are indicated. The reflective beach shows an n = 0 subharmonic edge wave (i.e., an half-incident wave frequency) with Guza and Davis (1974) predict as the most likely case, viz. the (o,o) triad. The troughless dissipative case shows a (1,0) edge wave triad; the same occurs in some bar-trough dissipative cases but in other cases is supplanted by the (o,o) subharmonic wave or by a lower subharmonic wave at quarter-incident frequency. The likelihood of a given edge wave set appears to be regulated by surf friction, and a change of edge wave set appears likely to explain observed changes of inshore circulation. (Authors)

52. CHIU, T-Y., and BRUNN, P., "Computations of Longshore Currents," *Proceedings of the Ninth Conference on Coastal Engineering*, Vol. 1, 1964a, American Society of Civil Engineers, p. 197.

Keywords: *Longshore mean current, Theoretical models, Mass concentration*

This article introduces the longshore current computations based on theories published under the title "Longshore Currents and Longshore Troughs" (Brunn, 1963). Two approaches are used to formulate the longshore current velocities for a beach profile with one bar under the following assumptions: (a) that longshore current is evenly distributed (or a mean can be taken) along the depth; (b) that the solitary wave theory is applicable for waves in the surf zone; (c) that the statistical wave height distribution for a deepwater wave spectrum with a single narrow band of frequencies can be used near the shore, and (d) that the depth over the bar crest, Dcr, equal 0.8 $H_{b(1/3)}$ (significant wave height).

Diagrams have been constructed for both approaches for beach profiles with one bar, from which longshore current velocities caused by various wave breaking conditions can be read directly. As for longshore currents along the beach with a multibar system, 15 diagrams covering a great variety of wave breaking conditions are provided for obtaining longshore current velocities in different troughs. (Authors)

53. CHIU, T., and BRUNN, P., "Computation of Longshore Currents by Breaking Waves," Technical Paper No. 279, Engineering Progress at the University of Florida, Gainesville, Fla., Mar. 1964b.

Keywords: *Longshore currents, Theoretical models, Mass conservation*

This paper also introduces the longshore current computations, as discussed in the previous reference.

54. COAKLEY, J.P., et al., "Sled System for Profiling Suspended Littoral Drift," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, pp. 1764-1775, 1978.

Keywords: *Measurement systems, Sleds, Longshore currents, Instruments*

This paper will describe a mechanical system designed to collect a series of time-averaged samples of suspended sediment for concentration determinations as well as flow velocity and water depth at locations across the surf zone. Some preliminary results of the field program using the system will also be presented and discussed. (Authors)

55. COASTAL ENGINEERING RESEARCH CENTER, "Modified Brunn Equation for Longshore Current Velocity," Library Copy No. QA211.U580, U.S. Army, Corps of Engineers, Washington, D.C., May 1969.

Keywords: *Longshore current, Theory*

According to the review by Galvin (1967), the equation producing the best agreement between prediction and measurement for the two better sets of longshore current velocity data is an equation derived from ideas presented by Bruun (1963). Since the ideas are presented rather obscurely in Bruun's paper and only outlined in Galvin's paper, there has been some question about the derivation leading to equation (12) of Galvin (1967).

The purpose of this report is to show how equation (12) in Galvin (1967) was derived from Bruun (1963). Since much of the difficulty in understanding is caused by symbols, pertinent symbols used by Bruun are listed, referenced and defined in Appendix I, and their correspondence with the symbols used by Galvin is shown in Appendix II, In addition, to avoid confusion when referring to equation numbers, all equations in this report are given an asterisk, e.g. (1*).

56. COKELET, E.O., "The Plunging Jet of a Breaking Wave," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Wave breaking, Wave theory, Numerical simulation*

In a breaking wave the region of primary interest is near the crest where the wave profile is very different from that of a steady, symmetric wave. To investigate this region, a series of numerical experiments was conducted using the method developed by Longuet-Higgins and Cokelet (1976) for free-surface flows. This technique is based on the fact that for an irrotational, incompressible fluid the kinematic and dynamic boundary conditions describe the evolution of the flow in terms of quantities specified only on the boundaries. (DHL)

57. COLLINS, J.I., "Longshore Currents and Wave Statistics in the Surf Zone," Report No. TC-149-2, Tetra Tech, Inc., Pasadena, Calif., Feb. 1972.

Keywords: *Longshore currents, Theoretical model, Random wave input, setup, Surf zone*

The report investigates some of the physical aspects of the surf zone with random seas. The statistics of wave height distributions are investigated for the surf zone over gentle sloping beaches. Longshore currents and wave setup due to random seas are computed and compared with results for periodic waves. The mathematical stability of steady longshore currents on plane beaches is investigated; such solutions are unstable. (Author)

58. COLLINS, J.I., "Wave Statistics in the Surf Zone, Nearshore Circulations, and Transformation of Wave Spectra: Final Report," Report No. TC-493-2, Tetra Tech, Inc., Pasadena, Calif., Aug. 1977.

Keywords: *Nearshore circulation, Theory, Irregular waves, State-of-the-art*

This final report summarizes more than 8 years' effort to improve the theory and understanding of coastal zone processes such as wave spectra modifications in shoaling waters and currents, longshore sediment transport mechanisms, and nearshore circulations including effects of bottom topography, winds, and waves. The basic problems are reviewed and all resulting progress and technical reports and journal publications resulting from this effort are summarized. An appendix contains a study of longshore current stability using perturbation methods. This procedure permits study of unstable edge wave modes.

59. COLLINS, J.I., and WIER, W., "Probabilities of Wave Characteristics in the Surf Zone," Report No. TT-TC-149, Tetra Tech. Inc., Pasadena, Calif., Sept. 1969.

Keywords: *Surf zone, Wave breaking probability distributions, Longshore current theory*

Utilizing the hydrodynamic relationships for shoaling and refraction of waves approaching a shoreline over parallel bottom contours, a number of probability distributions for breaking wave characteristics are derived in terms of assumed deepwater probability densities of wave heights, wavelengths, and angles of approach. Some probability densities for wave heights at specific locations in the surf zone are computed for a Rayleigh distribution in deep water. The probability computations are used to derive the expectation of energy flux at various locations in the surf zone. (Authors)

60. CRUMP, D.R., "Test Results on an Electromagnetic Current Sensor with an 'Open' Design," NOAA Technical Memorandum 19, National Oceanic and Atmospheric Administration, National Ocean Survey, Rockville, Md., Aug. 1976.

Keywords: *Currents, Instrumentation, Electromagnetic meter*

An electromagnetic current sensor with a unique "open" design was tested for steady-flow accuracy and cosine response in the horizontal and vertical planes. The sensor's configuration was designed to minimize hydrodynamic disturbances of the current flow and to offer good linearity and directivity response. Test data revealed the sensor's steady-flow measurement uncertainty to be ±2.5 percent of full scale.

Horizontal directivity errors were less than ±4 and 5 centimeters per second for 0.5- and 1-knot test flows. The major contributor of error for the cosine response was determined to be an imbalance in amplifier gain between the sensor's two measuring axes. Vertical directivity results were too noisy for reliable analysis, and the problem was believed to be caused by a distortion of the sensor's magnetic field during testing. (Author)

61. CUNNINGHAM, P.M., GUZA, R.T., and LOWE, R.L., "Dynamic Calibration of Electromagnetic Flow Meters," *Proceedings of Oceans '79*, Institute of Electrical and Electronics Engineers, Inc., Sept. 1979, pp. 298-301.

Keywords: *Measurement systems, Instrumentation, Velocity meters, Calibration*

A mechanical device for dynamic calibration of electromagnetic flowmeters was developed. This was used to calibrate flowmeters using simulated flows with various spectral characteristics. Current meter response was found to depend upon frequency, spectral content and amplitude of incident flows. Spurious mean flow signals from the flowmeters under certain flow conditions were investigated. (DHL)

62. CURREN, C.R., and CHATHAM, C.E., Jr., "Oceanside Harbor and Beach, California Design of Structures for Harbor Improvement and Beach Erosion Control; Hydraulic Model Investigation," *Coastal Research*, Vol. 5, No. 9, Oct. 1980, pp. 20-21.

Keywords: *Harbors, Hydraulic model tests, Longshore currents, Erosion*

A 1:100 scale (undistorted) hydraulic model, reproducing Oceanside Harbor, approximately 5.7 miles of shoreline, and sufficient offshore area to permit generation of the required test waves was used to investigate the arrangement and design of proposed structures for (a) improving navigation and mooring and prevention of shoaling of Oceanside Harbor, and (b) prevention of beach erosion. The proposed structures for mitigation of beach erosion consisted of various groin and offshore breakwater configurations. A 190-foot-long wave generator, crushed coal tracer material, and an automated data acquisition and control system (ADACS) were used during model operation. (Authors)

63. DALRYMPLE, R.A., "A Mechanism for Rip Current Generation on an Open Coast," *Journal of Geophysical Research*, Vol. 80, No. 24, Aug. 1975, pp. 3485-3487.

Keywords: *Nearshore circulation, Rip currents, Wave interaction theory*

Intersecting ocean wave trains of the same frequency will create periodic longshore variations in the mean water level both inside and outside the surf zone. In the surf zone this creates a longshore variation in wave height and wave-induced circulation, as described by Bowen, but previously attributed to edge waves and irregular bottom topography. (Author)

64. DALRYMPLE, R.A., "A Bibliography on Rip Currents," *Proceedings of a Workshop on Coastal Sediment Transport*, Technical Report DEL-SG-15-78, Department of Civil Engineering, University of Delaware, Dec. 1976, pp. 59-62.

Keyword: *Rip currents*

The bibliography is divided into two major categories: theory and field observations. Theory subheadings include edge waves, wave current interaction, periodic bottom topography, intersecting wave trains, instability theory, infra gravity, structurally induced, longshore bar induced, rip dynamic. Field observation category includes 14 papers.

65. DALRYMPLE, R.A., "Rip Currents and Their Causes," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1978, pp. 1414-1427.

Keywords: *Rip currents*

This paper categorizes and reviews the more recent theories for rip current generation and discusses a simple model for rip currents on barred coastlines. (DHL)

66. DALRYMPLE, R.A., "Longshore Currents with Wave Current Interaction," *Journal of the Waterway, Port, Coastal and Ocean Division*, Vol. 106, No. WW3, Aug. 1980, pp. 414-420.

Keywords: *Longshore currents, Theoretical model, Wave-current refraction*

Longshore currents generated by waves breaking at large oblique angles to the coastline are examined analytically, along with refraction ef-

fects by the longshore currents. Only planar beaches and the case of no lateral momentum transport are studied. It is concluded that if corrections to the Longuet-Higgins (1970) formula for longshore current profile decrease the shear stress in the surf zone, then the surf zone width must increase. This is because the total Sxy remains the same but current and stress are reproportioned.

67. DALYRMPLE, R.A., and DEAN, R.G., "Spiral Wave Maker for Littoral Drift Studies," *Proceedings of the 13th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. I, 1972, pp. 689-705.

Keywords: *Laboratory experiments, Wave basins, Longshore currents*

A technique for simulating an infinitely long beach in the laboratory is introduced, with the objective of eliminating end effects usually present with short, straight beach sections. The technique involves the spiral wavemaker generating waves in the center of a circular basin.

The wavemaker, consisting of a vertical right-circular cylinder oscillating in a small circle about its axis, is described in detail. Theoretical developments, using small-amplitude wave assumptions, show that the surface wave crests generated by the wavemaker may be described, at a particular time, as an Archimedian-type of spiral, with the wavemaker at its origin. Also, the crests impinge on the circular beach everywhere at the same angle of incidence.

Experiments with a prototype spiral wavemaker verify the theory, with close results for shallow-water waves. Littoral drift applications of the wavemaker are given. (Authors)

68. DALRYMPLE, R.A., and LANAN, G.A., "Beach Cusps Formed by Intersecting Waves," *Bulletin of the Geological Society of America*, Vol. 87, No. 1, Jan. 1976, pp. 57-60.

Keywords: *Wave theory, Wave interactions, Rip currents*

From the time when theories were first postulated on beach cusps, intersecting wave trains have been mentioned as one possible mechanism for cusp formation. However, this mechanism has been largely ignored, and no real effort has been made to understand it since Branner (1900). It can be experimentally shown that rip currents, generated by intersecting waves of the same length, can create beach cusps of a known periodicity that depends on the wavelength and the angle between the intersecting wave trains. (Authors)

69. DALRYMPLE, R.A., and LOZANO, C.J., "Wave Current Interaction Model for Rip Currents," *Journal of Geophysical Research*, Vol. 83, No. 12, Dec. 1978, pp. 6063-6071.

Keywords: *Nearshore circulation, Theoretical models, Wave-current refraction, Rip current cells*

Two analytical models are developed to describe rip current cells on an open coastline with sloping planar foreshore and flat offshore bathymetry. Both models extend the work of LeBlond and Tang (1974) to include the refraction of the normally incident wave field by the neashore circulation. The first model includes the effect of the currents on the incident wavelength, but no change in wave direction, and show that no rip currents are possible. The second more complete model considers the refraction of the waves as well and predicts rip current cells. The spacing of the rip currents and their associated variables are shown to be a function of one dimensionless parameter. Comparison of the predicted spacing with some published field data as well as with measurements obtained on the Isle of Sylt, West Germany, shows reasonable agreement with the second model. (Authors)

70. DALRYMPLE, R.A., EUBANKS, R.A., and BIRKEMEIER, W.A., "Wave Induced Circulation in Shallow Basins," *Journal of the Water, Port, Coastal and Ocean Division*, Vol. 103, No. WWI, Feb. 1977, pp. 117-135.

Keywords: *Longshore currents, Laboratory basins, Model basin designs*

Water waves in model basins are used to study longshore currents on beaches. Due to the limited length of basins, return flows are engendered, which are not representative of nature. Using a simplified analytical theory, the transport stream function for three common model basin setups are found. Verification of the major features of the stream function was carried out in a small wave tank. Conclusions concerning adequate basin sizes to model longshore currents are made. (Authors)

71. DAVIS, R.A., and FOX, W.T., "Coastal Processes and Nearshore Sand Bars," *Journal of Sedimentary Petrology*, Vol. 42, No. 2, June 1972, pp. 401-412.

Keywords: *Longshore currents, Climatological variables, Barometric pressure variations, Coastal geomorphology*

Detailed daily topographic maps of beach and inner nearshore areas

indicate a cyclic pattern to processes and responses in this nontidal environment. This pattern is the result of complex interaction between changes in shoreline configuration, discontinuous nearshore sandbars, and environmental variables such as barometric pressure, wind velocity, breaker height, and longhsore currents. Of the 18 variables measured, *barometric pressure* appears to provide the best index for changes in coastal processes. The results of these variations are morphologic changes in the beach and inner nearshore area.

As a low-pressure system approaches the coast there is an increase in wind velocity, breaker height, and longshore current velocity as barometric pressure drops. When the low-pressure system passes, barometric pressures rises and there is a reversal of wind direction with an accompanying reversal of longshore current direction. (Authors)

72. DAVIS, R.E., and GUZA, R.T., "Excitation of Edge Waves by Waves Incident on a Beach," *Journal of Geophysical Research*, Vol. 79, No. 9, Mar. 1974, pp. 1285-1291.

Keywords: *Water waves, Edge waves, Theoretical frequencies*

It is shown theoretically that surface waves incident on a beach from deep water can excite edge waves. In particular, a standing wave normally incident on a beach of constant gentle slope is found to transfer energy to edge waves through a weak resonant interaction resulting from an instability of the incident wave with respect to perturbation by edge waves. The analysis is based on the shallow-water approximation and ignores the earth's rotation and consequently applies only to relatively low mode, high-frequency waves. Coupling coefficients, frequencies, and longshore wave numbers of the excited wave are given. In accordance with Hasselmann's (1967) rule, only edge waves with frequencies lower than the frequency of the incident wave are excited by this mechanism. Viscous effects suggest that an edge wave with a frequency one-half that of incident wave is preferentially excited. (Authors)

73. DEAN, R.G., ed., "*Proceedings of a Workshop on Coastal Sediment Transport*," Technical Report DEL-SG-15-78, Department of Civil Engineering, University of Delaware, Newark, Del., Dec. 1976.

Keywords: *Nearshore currents, Longshore currents, Rip currents, Sediment transport, State-of-the-art*

A workshop was conducted to explore the possibilities for a broad-based and collective effort to study nearshore sediment transport problems under the National Sea Grant Program. State-of-the-art summaries presented by 13 speakers provided an update and forum for discussion. Brief summaries on longshore and rip currents were presented.

74. DELFT HYDRAULIC LABORATORY, "Water Motion in a Coastal Model With Fixed Bottom," T.O.W. Report M918, Part 4, 1977, Delft Hydraulics Laboratory, Delft, The Netherlands (in Dutch).

Keywords: *Longshore currents, Laboratory experiments, Measurement techniques*

Report discusses a series of experiments using floats, dye, propeller-type and ott-type miniature current meters in the surf zone to select the best technique for measuring longshore currents. To eliminate the influence of the wave orbital velocity on the measurements with dye, it was determined that the dye needed to be injected during different phases of the wave and averages determined. Dye was selected as the best laboratory method.

75. DETTE, H.H., "Field Study of Longshore Currents," Braunschweig. Technischen Universitat. Leichtweiss-Instituts Fur Wasserbau. Mitteilungen 41, 1974a(in German with an English Abstract).

Keywords: *Field measurements, Electromagnetic current meter, Surf zone*

Field measurements with electromagnetic current meters in the surf zone at Sylt, North Sea, were analyzed to study the time-dependent nature of the longshore currents. It was found that the longshore currents *cannot* be treated any longer as steady or quasi-steady flows which can be described by mean values. Time variations of ±100 percent with as many as nine periodical fluctuations occurred within one wave period. Mean values up to 1.5 meters per second were recorded. A dimensionless, periodical fluctuation parameter is proposed to describe the degree of fluctuation within the longshore currents. The appendix included a review of longshore current formulas and a comparison of computed and measured data.

76. DETTE, H.H., "Wellenmessungen und Brandungsuntersuchungen vor Westerland/Sylt," Heft 40, Mitteilungen eichtweiss-Institut für Wasserbau der T.U. Braunschweig, 1974b, pp. 285-330.

Keywords: *Sediment transport, Surf zone, Measurements, Intrumentation, Field studies*

A beach nourishment program was carried out in 1971-72, and investigations on how wave forces distributed 700,000 cubic meters of sand were made. A description is given of the continuous wave measurements carried out from 1971-74. The paper deals with: description of the program, purpose of the measurements, description of instrumentation (ultrasonic wave recorders, wave and breaker measurements in the surf zone, recording orbital velocities and longshore currents), and evaluation of the results. (DHL)

77. DETTE, H.H., and FUHRBOTER, A., "Field Investigations in Surf Zones," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974, pp. 518-537.

Keywords: *Surf zone, Field measurements, Instrumentation, Longshore current velocities*

During storm surges considerable wave energies are dissipated in surf zones; the energy transfer rates are in the order of one up to two powers of ten higher than outside the surf zone. A breaker parameter β introduced by Fuhrboter (1974) with regard to a quantitative breaker classification, especially of the intermediate types between surging and spilling, was found to be convenient for practical application. The breaker parameter β is in close relation with the horizontal asymmetry parameter α of the breaking wave. With decreasing breaker parameter the asymmetry is increased and reversed.

Within the longshore currents macroturbulences were discovered. The periodical fluctuation parameter γ was found to increase nearly linearily with decreasing breaker parameter; the narrower the area is, where the main energy is dissipated the smaller becomes the mean periodical fluctuation which seems to be independent of the wave period but reaches up to seven and more fluctuations within the wave period.

The mean longshore currents velocities reached up to 1.5 meters per second above the sea bottom; the coefficient of variation was scattering considerably between 400 percent at low velocities ($\bar{v}_L$ = 0.1 meter per second) and 20 percent at the highest velocities ($\bar{v}_L$ = 1.5 meters per second). The instantaneous longshore current velocities were nearly symmetrically distributed around the mean velocity, the mean amplitudes were nearly constant and reached approximately 0.35 meter per second, whereas the periodical fluctuation decreased from 2.6 seconds at low mean velocities to 1.7 seconds at high velocities. (Authors)

78. DIVOKY, D., LE MEHAUTE, B., and LIN, A., "Breaking Waves on Gentle Slopes," *Annual Meeting and National Meeting on Water Resources Engineering*, American Society of Civil Engineers, Feb. 1969, pp. 1-28.

Keywords: *Wave breaking, Model experiments, Velocity measurements*

Large-amplitiude waves may form spilling breakers over a very gentle slope. A theoretical and experimental analysis of such waves is presented. In particular, the rate of energy dissipation as a function of bottom slope and convergence of wave orthogonals is determined theoretically and experimentally and related to the relative height of foam, "white water," appearing in front of the breaker. The velocity field in gentle spilling breakers was measured. (DHL)

79. DOBSON, P.J., and DRAPER, L., "Rip Currents on Cornish Beach," *Nature*, London, England, Vol. 206, No. 4990, June 1965, p. 1249.

Keywords: *Field observations, Instrumentation, Rip currents*

Rip currents have been measured at Holywell in West Cornwall, where a sandy beach is open to waves and swells from the Atlantic. A rip current is a narrow streak of water which flows seaward from the beach; it carries the return flow of the general shoreward transport of water produced by the breaking waves. Such currents cause many bathing fatalities each year.

The currents were measured by observing the speed of floating objects, or of foam on the surface, by means of a theodolite mounted on an adjacent promontory. Speeds of almost 5 knots were observed when the incoming swell reached about 10 feet in height and when there was a slight onshore wind blowing. The rips were observed to travel out from the shore for as far as 900 feet, it is quite possible that they traveled farther but the situation of the observation post made quarter distances difficult to measure.

Results under heavy swell were as follows: the measurements were of the mean speed more than 1 minute.

In the surf zone. Average of seven measurements: 276 feet per minute (maximum: 330 feet per minute, minimum: 209 feet per minute)

Seaward of the surf zone. Average of six measurements: 143 feet per minute (maximum: 209 feet per minute, minimum: 113 feet per minute)

Holywell beach is probably typical of many beaches on the Atlantic coasts of Western Europe, so that it can reasonably be expected that rip currents of this magnitude will occur in many such places. (Authors)

80. DORRESTEIN, R., "Theory of Wave Set-Up," U.S. Army, Corps of Engineers, Beach Erosion Board, Library Copy No. QA927.012, Washington, D.C., 1961.

Keywords: *Wave setup, Wave theory*

This paper, which was never published, concentrates on the wave setup theory. The momentum equation is incorrectly applied and such theories have subsequently been replaced by wave thrust (radiation stress) concepts.

81. DORRESTEIN, R., "Wave Set-Up on a Beach," *Proceedings, Second Technical Conference on Hurricanes,* 1962, pp. 230-241.

Keywords: *Field experiments, Wave setup*

When waves are running toward a coast, the water level near the shoreline, averaged over a period of a few minutes, is higher than the corresponding average level in deeper water (apart from a possible wind effect). The difference is termed the wave setup. This wave setup supplies the average, outward pressure force necessary to compensate for the average transfer of horizontal momentum (normal to shore) toward the coast, caused by the waves. In this present paper some field observations made at the fishing pier at Fernandina Beach on the Atlantic coast of Florida are described, and the results are used to check the validity of a simplified theory related the wave setup to the wave properties in relatively deep water. (Author)

82. DYHR-NIELSEN, M., and SORENSEN, T., "Sand Transport Phenomena on Coasts with Bars," *Proceedings of the 12th Conference on Coastal Engineering,* American Society of Civil Engineers, Vol. 2, 1970, pp. 855-865.

Keywords: *Longshore currents, Transverse secondary currents, Sediment transport*

Longshore wave currents and their influence on the sand transport phenomena in the shore zone have attracted the attention of numerous researchers. Also the existence of transverse, secondary currents, superposing the longshore component, has been known for years, but less attention has been given to analysis of their effect on the sediment movement. This paper presents some examples of the influence these relatively weak transverse currents may have on the processes in the shore zone. They have a parallel in the effect of secondary currents in alluvial streams, which, although weak, give rise to such an impressive phenomenon as meandering. All conclusions are based on simple, qualitative considerations of the physics of the system. (Author)

83. EAGLESON, P.S., "Uniform Longshore Currents on a Plane Beach," Staff Publication 92, Massachusetts Institute of Technology, Hydrodynamics Laboratory, Cambridge, Mass., 1964.

Keywords: *Longshore currents, Theoretical model, Surf zone mass continuity, Laboratory experiments*

Measurements made of the characteristics of breaking waves and the resulting longshore currents for 34 combinations of wave height (up to 0.22 foot), period (0.40 to 1.50 seconds) and breaker angle (up to 32°) along a 20-foot test section of a 30-foot plane, smooth concrete beach with slope of 0.104. Observations and measurements show that most of the fluid in the surf zone stays there, and that longshore current velocity initially increases downstream from an obstacle. Velocity increases along the beach because the fluid forming the breaking wave has been withdrawn from the surf zone and thus already has a longshore component of motion of the breaking wave. A differential equation for this nonuniform flow agrees qualitatively with the measured variation of velocity with breaker angle and with distance from an obstacle. The nonuniformity of the flow was also indicated by the mean water level, which increased, and the breaker position and runup limits, which moved shoreward, downstream from the obstacle, but there is a possibility that these measurements were affected by the experimental apparatus. The energy used to maintain the flow of longshore currents is a small fraction (less than 1/10) of the energy brought to the surf zone by shoaling waves. The mean velocity of uniform longshore currents is approximately given by $V = gmT \sin 2\theta_b$, an equation which is one form of the conservation of mass (continuity) in the surf zone.

84. EAGLESON, P.S., "Theoretical Study of Longshore Currents on a Plane Beach," Report R65-28, Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, Mass., 1965.

Keywords: *Longshore currents, Theoretical model, Surf zone mass continuity, Laboratory experiments*

This study is described in the previous reference.

85. EAGLESON, P.S., "Growth of Longshore Currents Downstream of a Surf-Zone Barrier," *Coastal Engineering Specialty Conference*, American Society of Civil Engineers, Oct. 1965, pp. 487-507.

Keywords: *Mean longshore current, Theoretical model, Momentum flux, Laboratory experiments*

Momentum flux considerations are used to formulate a differential equation governing the growth, with distance, of the mean longshore current velocity in the surf zone on a plane, impermeable beach due to monochromatic waves. The equation is solved for the flow situation downstream of a surf zone barrier and is shown to compare favorably with laboratory measurements. The asymptotic (uniform flow) form of the relation is also shown to be in good agreement with the field and laboratory data of other investigators.

Conclusions are reached governing the size of laboratory models necessary to represent conditions of fully developed longshore currents. (Author)

86. EARLE, M.D., "Longshore Currents Generated by Waves with a Rayleigh Wave Amplitude Distribution," *Annual Meeting, American Geophysical Union*, Washington, D.C., Apr. 1974.

Keywords: *Longshore currents, Wave theory, Irregular waves*

Longshore currents due to incident waves of varying heights approaching a straight coastline are determined. The equation of motion for the longshore current depends on the radiation stress associated with the incident waves, a Rayleigh distribution of incident wave amplitudes, bottom friction, and horizontal mixing. In a dimensionless form, this equation is solved by series to obtain horizontal current profiles which differ from current profiles for incident waves with a constant height. The series solution is extended to consider the effects of wave shoaling. Wave shoaling causes the current velocities to increase near the coastline and to decrease away from the coastline. For applications, the current profile results can be related to several measures of the incident wave height such as significant wave height, root-mean-square wave height, or the total energy of a wave spectrum. (Author)

87. EBERSOLE, B.A., and DALRYMPLE, R.A., "A Numerical Model for Nearshore Circulation Including Convective Accelerations and Lateral Mixing," Technical Report No. 4, Ocean Engineering Report No. 21, Department of Civil Engineering, University of Delaware, Newark, Del., July 1979.

Keywords: *Nearshore circulation, Wave theory, Numerical model*

A finite-difference model for predicting the nearshore circulation due to wind and waves is presented which attempts to solve the same problem as an earlier model created by Birkemeier and Dalrymple (1975). Their model iteratively solved the linear set of conservation equations of both mass and momentum, which were time averaged (over one wave period) and depth integrated, for mean velocities and free surface displacements. The wave characteristics used in the momentum equations were found using the wave refraction and shoaling routines, including wave-current interaction, developed by Noda, et al. (1974). The model also included a linear bottom friction formulation as well as a surface wind stress capability.

The present model discussed herein includes the addition of convection accelerations, horizontal mixing and a quadratic bottom friction term in the conservation of momentum equations. This bottom friction term is "exact" in the sense that it includes the velocity vectors due to both mean and wave-induced currents. The model is applied to the cases of a single wave train impinging on a plane beach, a barred profile, and a bottom with a periodically spaced rip channel. It is also applied, in a simplified form, to the case of two intersecting wave trains at oblique angles to a plane beach. Results indicate that these additions to the model are important in attempts to model the circulation patterns over bottom bathymetries found in nature. (Authors)

88. EBERSOLE, B.A., and DALRYMPLE, R.A., "Numerical Modelling of Nearshore Circulation," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Nearshore circulation, Numerical model, Lateral turbulent mixing*

A numerical finite-difference scheme is devised using a leapfrog operator to integrate the unsteady, two-dimensional, depth-averaged, time-averaged, nearshore equations of motion and continuity. Time-averaging the presence of waves creates the excess momentum flux (radiation stress) terms. The equations include the nonlinear convective accelerations and lateral turbulence (mixing) terms. The wave energy and direction needed for the radiation stresses is calculated independently using a wave refraction procedure that includes wave-

current interaction. The usual wave breaking index model is used to locate the breakers and decay the wave energy in the surf zone. A comparison of the computed results versus the analytical longshore current profiles on a plain beach (Longuet-Higgins, 1970) was made. It revealed the excessive numerical mixing (dispersion) present in the finite-difference analog which is only first-order accurate in the space derivatives. The explicit nature of the scheme also required running at time steps significantly lower than necessary for stability reasons. This also contributed to the inaccuracy of the computations. In effect the physical, eddy viscosity term is masked by the presence of excessive numerical "viscosity." Subsequent plots of numerical nearshore circulations and rip currents can be completely erroneous for this reason.

89. ELIOT, I., "The Persistence of Rip Currents on Sandy Beaches," Engineering Dynamics of the Coastal Zone, *First Australian Conference on Coastal Engineering*, National Conference Publication No. 73/1, The Institute of Engineers, Australia, 1973, pp. 29-34.

Keywords: *Rip currents*

Water current patterns on sandy beaches are subject to rapid change when the direction or amount of energy input varies. Despite this the location of rip currents is often persistent. The relationship between the number of rip currents and the longshore velocity is also investigated. (Author)

90. FILIMONOV, A.I., "Use of the Alekseyev System of Recording Current Meters for Study of Nearshore Currents," *Oceanology*, Academy of Sciences, U.S.S.R., Vol. 5, No. 6, 1965, pp. 126-129.

Keywords: *Longshore currents, Measurement systems, Instrumentation*

Areal survey of longshore currents performed with the aid of an Alekseyev system of recording current meters requires little expenditure of time and labor. For nearshore work the BPV-2r, which weighs only 28 kilograms, is the most suitable current meter. Measurements taken with recording current meters are in good agreement with results obtained from tensometric gages and short-term recording of provisional pressure values. Using recording current meters, calculations of the flow rate and interrelationship of water movement along the shore and normal to it.

Several possible ways of installing recording current meters in nearshore waters are discussed, and the following three methods used in studies of longshore currents are described: (a) mounting the recording current meters on tripods, (b) mounting recording current meters on frames, and (c) mounting recording current meters on buoys.

91. FISHER, J.S., and DOLAN, R., eds., *Beach Processes and Coastal Hydrodynamics*, Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pa., 1977.

Keywords: *Coastal sediment, Nearshore processes*

Bench-mark papers in geology series were divided into three categories: I. Historical Milestones, II. Coastal Hydrodynamics, III. Beach Processes. The book is a valuable must for both new and old researchers in the field.

92. FORREST, D.R., and SAVILLE, T., Jr., "Comparison of Measured and Computed Longshore Currents at Mission Bay, California," U.S. Army Corps of Engineers, Beach Erosion Board, Washington, D.C., unpublished, 1951.

Keywords: *Longshore currents, Wave theory, Field experiments*

Longshore current measurements and observations of wave period, height, and direction were made twice daily at three stations from December 1949 to the first 6 months of 1951. Using these data longshore current velocity was computed using the equation developed by Putnam, Munk, and Traylor (1949) and revised by Inman and Quinn (1950). Currents were measured for 3 minutes at a single point at each station. During this period fluctuations in velocity were sometimes apparent with occasional reversals in direction and were more noticeable when the waves broke nearly parallel to shore. Obtaining a velocity measurement at one point for a short time interval is not representative of longshore current velocity. Longshore currents are seldom uniform in velocity but fluctuate with respect to time and location.

Agreement between observed and predicted longshore currents is very poor. This is due to not only the inadequacies in the equations employed, but also the wave data collected. Breaker angles were obtained from refraction diagrams. Deepwater wave heights were estimated by eye. Thus, insufficient raw data are the primary deficiency noted in the report.

93. FOX, W.T., and DAVIS, R.A., Jr., "Computer Simulation Model of Coastal Processes in Eastern Lake Michigan," Technical Report No. 5, Williams College, Williamstown, Mass., Dec. 1971.

Keywords: *Longshore currents, Field measurements, Statistical analysis*

A computer simulation model is used to study the relationship among barometric pressure, wind, waves, longshore currents, beach erosion, and and bar migration on the eastern shore of Lake Michigan. Harmonic trend analysis with a single Fourier series represents the major trends in weather and wave parameters. In the simulation model, barometric pressure is plotted as a function of time and longshore current velocity is computed as the first derivative of barometric pressure. Breaker height closely approximates a modified form of the second derivative of barometric pressure.

Daily profiles provide data for nearshore topographic maps. For the simulation model, the nearshore area is broken down into components including beach, foreshore, plunge zone, trough and bar. A gently sloping linear plus quadratic surface represents the barless topography in the nearshore area. Bars and troughs generated by normal and inverted normal curves are superimposed on the linear plus quadratic surface.

Wave and longshore current energies are computed for storm cycles and poststorm recovery periods. Bar distance is computed as a function of wave energy and bottom slope. Bar migration is a function of longshore current energy. Variations in the position of the plunge zone and nearshore bar along the shore are simulated using a sine function. Simulated maps are produced for each storm cycle and poststorm recovery period. (Authors)

94. FOX, W.T., and DAVIS, R.A., Jr., "Coastal Storm Model," Technical Report No. 14, Williams College, Williamstown, Mass., Apr. 1976.

Keywords: *Longshore currents, Wave theory, Stochastic models*

A mathematical simulation model of a coastal storm has been programed to forecast or hindcast wave and longshore current conditions at a coastal site. Storm parameters for the model are based on the size, shape intensity, and path of the storm as derived from weather maps.

An elliptical form is used to model the size and shape of the storm which are controlled by varying the length and orientation of the major and minor axes. Storm intensity is a function of the barometric pressure gradient which is modeled by an inverted normal curve through the storm center. The storm path is based on actual storm positions for the hindcast mode, and on projected positions assuming constant speed and direction for the forecast mode. The location, shoreline orientation, and nearshore bottom slope provide input data for each coastal site.

For each storm position, the geostrophic wind speed and direction are computed at the shore site as a function of barometric pressure gradient and latitude. The geostrophic wind is converted into surface wind speed and direction by applying corrections for frictional effects over land and sea. The surface wind speed, fetch, and duration are used to compute the wave period, breaker height, and breaker angle at the shore site. The longshore current velocity is computed as a function of wave period, breaker height and angle and nearshore bottom slope.

The model was tested by comparing hindcast output with observed data for several coastal locations. Forecasts were made for actual storms and for hypothetical circular and elliptical shaped storms. (Authors)

95. FUHRBOTER, A., "Air Entrainment and Energy Dissipation in Breakers," *Proceedings of the 12th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1970, pp. 391-398.

Keywords: *Surf zone*

Inside the surf zone, wave height and energy are reduced suddenly by strong interactions; it shall be demonstrated here that the major part of wave energy is spent by surface interaction-air entrainment. For this demonstration, only simple assumptions and linear wave theory are used; the results would be essentially the same for higher order theories. (Author)

96. FUHROBOTER, A., "Uber die Bedeutung des Lufteinschlages fur die Energieumwandlung in Brandungszonen," (The Influence of Air Entrainment for Energy Dissipation in Breakers) Heft 36, Mitteilungen des Franzius-Instituts Für Grund-und Wasserbau der Technischen Universität Hannover, 1971, pp. 1-16.

Keywords: *Wave breaking*

97. FUHRBOTER, A., "Nige Ergebnisse aus Naturuntersuchungen in Brandungszonen," Mitteilungen Leichtweiss-Institut für Wasserbau der Technical University Braunschweig, No. 40, 1974, pp. 331-371.

Keywords: *Surf zone, Breaking waves, Field measurements*

In a measuring profile 1,280 meters long off Sylt, North Sea, which crosses a longshore bar, comprehensive wave and surf investigations were carried out. A proposal for quantitative classification of breakers is given based on the relation of a half-decay length to the wavelength at the breaking point. (DHL)

98. FUHRBOTER, A., and BUSCHING, F., "Wave Measuring Instrumentation for Field Investigations on Breakers," *Proceedings of the International Symposium on Ocean Wave Measurement and Analysis*, American Society of Civil Engineers, Vol. 1, 1974, pp. 649-668.

Keywords: *Wave measurement, Measurement technology, Instruments*

As water-air interaction cannot be simulated completely in a model, laboratory investigations on breakers can only be reliable to a certain extent. This is why comprehensive field investigations are necessary; a program of such field measurements was started on the isle of Sylt, North Sea in 1971. The measurements analyzed were carried out in the surf zone during a severe storm surge. The measuring devices consisted of a two-component electromagnetic current meter and a wave meter placed on the beach at a distance of 85 meters from the coastline; another wave meter was located 15 meters offshore. To use different analyzing methods, the outputs of the measuring devices were fed simultaneously to a magnetic-tape recorder.

For the purpose of data processing on a pulse height analyzer the signals had been chopped by a frequency of 20 kilocycles. Thus the stochastic process could be displayed on a scope as histograms representing 10 minutes real time measuring periods.

From the histograms statistical parameters are obtained to a high degree of accuracy.

For the correlation of water levels and orbital velocities, power spectra, cross-power spectra, transfer functions, and coherence functions are calculated by the use of a Fourier analyzer. (Authors)

99. GABLE, C.G., ed., "Report on Data from the Nearshore Sediment Transport Study Experiment at Torrey Pines Beach, California, November-December 1978," IMR Reference [illegible] Marine Resources, LaJolla, Calif., Dec. 1979.

Keywords: *Field experiments, Instrumentation, Data acquisition systems, Coastal measurements, Tennessee*

This is the first report to provide Nearshore Sediment Transport Study field data access information and a description of each major field experiment. The report includes:

(a) The purpose and objectives of this experiment and its relationship to the overall NSTS program.
(b) Details of the physical setting for the experiment necessary to evaluate the significance of the various measurements.
(c) A precise identification of the kind of measurements obtained, including duration, time, quality of data, location of instrument, calculating history, relationship to adjacent instruments, etc.
(d) Sufficient information to allow the investigator to extract meaningful data from the magnetic data tapes and data tables.
(e) Where and how to receive the data tapes that supplement this report.

100. GALVIN, C.J., "Experimental and Theoretical Study of Longshore Currents on a Plane Beach," Ph.D. Dissertation, Massachusetts Institute of Technology, Cambridge, Mass., 1963.

Keywords: *Longshore currents, Laboratory experiments, Theory*

Measurements were made of the characteristics of breaking waves and the resulting longshore currents for 34 combinations of wave height (up to 0.22 foot), period (0.90 to 1.50 seconds), and breaker angle (up to 32°), along a 20-foot test section of a 30-foot, plane, smooth concrete beach with a 0.104 slope. The velocity of longshore currents generated on a laboratory beach by plunging breakers depends largely on breaker angle (θ_b) and position along the beach. θ_b determines the longshore component of momentum flux in the breaking wave, and this quantity increases in the downstream direction as the breaker is formed from fluid in the surf zone already moving with a longshore velocity. A differential equation for this nonuniform flow of longshore currents agrees qualitatively with the measured variation of velocity with breaker angle and distance. Mean water level also increases and the breaker position and runup limit move shoreward, in the downstream direction. Energy is dissipated in the surf zone chiefly by the wave breaking and to a lesser extent by the bore in the runup region. The flow of the longshore current dissipates little energy. Longshore current velocity on a laboratory and a natural beach is approximately equal to the product of g, beach slope, wave period, and sin $2\theta_b$. (Author)

101. GALVIN, C.J., "Resonant Edge Waves on Laboratory Beaches," *Transactions of the American Geophysical Union*, Vol. 46, No. 1, Mar. 1965, p. 112.

Keywords: *Edge waves, Laboratory experiments*

Resonant waves have been produced whose period T and wavelength L are related to beach slope α, according to Stokes' edge wave equation, $L = (g/2\pi)T^2 \sin\alpha$. In a tank of width L/2 the resonance appears at the shoreline when small-amplitude water waves arrive with a period of T/2. During resonance, the runup from successive forcing waves at an antinodal position alternates between a maximum and a minimum, and the maximum at one antinode occurs simultaneously with minimums at the neighboring antinodes. Resonance occurs over a narrow band of periods including the edge wave period. As the amplitude of the forcing wave increases from a very low value, the bandwidth for resonance first increases, then decreases; finally, above a forcing amplitude which is still relatively low, the resonance no longer occurs. These waves developed on eight-plane beaches, with slopes ranging from 6° to 20.5°, and on a wide sand beach of variable slope. On the sand beach as many as 17 antinodes developed simultaneously, and occasionally the antinodes produced beach cusps. The possibility that surf beat or larger scale geophysical phenomena are edge waves should be reexamined when the forcing period is half that of the period to be explained. (Author)

102. GALVIN, C.J., Jr., "Longshore Current Velocity: A Review of Theory and Data," *Reviews of Geophysics*, Vol. 5, No. 3, Aug. 1967, pp. 287-304 (also Reprint 2-68, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Aug. 1968).

Keywords: *Longshore currents, Wave theory, Experiments, State-of-the-art*

A proven prediction of longshore current velocity is not available, and reliable data on longshore currents are lacking over a significant range of possible flows. Theoretical studies have been based on oversimplified models, and empirical predictions have been hampered by lack of data. The empirically modified, momentum flux theory now accepted as the best prediction is based on an untenable assumption and supported by inappropriate data. Regardless of their validity, however, all six of the testable equations agree fairly well with at least one of six sets of published data, and two agree with both of the better sets of data. These two equations may be used as empirical guides for velocity prediction in the absence of a proven theory. The best prospect for a generally valid velocity prediction appears to be an empirical correlation based on reliable data. (Author)

103. GALVIN, C.J., Jr., "Shapes of Unbroken, Periodic Gravity Water Waves," *Transactions of the American Geophysical Union*, Vol. 49, No. 1, Mar. 1968, p. 206.

Keywords: *Wave theory*

Water waves are generated by the periodic, nearly sinusoidal, horizontal motion of a vertical flat plate at one end of a long, constant depth wave tank. Generator period and amplitude, and stillwater depth (d) ranged, respectively, from 1.0 to 8.0 seconds, 2.5 to 24 centimeters, and 15 to 38 centimeters, giving d/L ratios from 0.018 to 1.0 and H/d ratios from 0.01 to 0.63. H is measured wave height and L is wavelength for given depth and period from linear theory. Wave shape, the time-history of the water surface at a point, was recorded from a wire-resistance gage for 137 conditions. Over the range tested, breaking occurred in the constant depth part of the tank for conditions above a curve approximated by $\ln(d/L) = 0.9 - 6.4\,(h/d)$. Unbroken conditions near this curve but above d/L = 0.3 produced irregular waves of the Benjamin-Feir type. Conditions in the region $d/L < 0.09$, $H/D > 0.05$ produced interacting solitons (secondary waves). The number of solitons increased as d/L decreased and was relatively independent of H/d. At lowest (H/d, d/L) conditions, interactions resulted in confused wave firms. Regular periodic waves were limited to the remaining region, largely $0.37 > d/L > 0.09$. These data restrict the applicability of classical theories of waves of permanent form. (Author)

104. GALVIN, C.J., Jr., "Finite-Amplitude, Shallow Water-Waves of Periodically Recurring Form," Reprint 5-72, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Sept. 1972.

Keywords: *Wave theory, Solitons, Laboratory experiments*

Finite-amplitude, periodic, sinusoidal waves generated in constant-depth shallow water break down into two or more waves traveling at speeds dependent on their height. These waves are here called solitons (waves resembling solitary waves) after an analogous phenomenon in plasma physics. A large soliton overtakes previously generated smaller solitons, and the amplitude of the larger wave temporarily decreases during the resulting interaction. This decrease in amplitude can be

qualitatively explained by the acceleration and spreading of the larger wave when its leading edge encounters the deeper water on the smaller wave.

The larger wave regains its initial amplitude on passing through the smaller wave. If followed long enough, the interacting solitons periodicially assume the initial waveform. All properties of the laboratory experiments are found in numerical solutions of the Korteweg-deVires equation (Zabusky and Kruskal, 1965) which show the solitons to be interacting solitary waves. These results indicate that the initial sinusoidal waveform produced by the wave generator can be thought of as the forced superposition of a number of solitary waves. (Author)

105. GALVIN, C.J., Jr., "Wave Breaking in Shallow Water," Reprint 4-73, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Mar. 1973.

Keywords: *Breaking parameters, Classifications, Empirical.*

Deepwater steepness (H_o/L_o) and beach slope (m) determine breaker type and breaker depth-to-height ratio. High initial H_o/L_o induces breaking in deeper water since steepness grows faster than height. Slope determines the extent of nonlinear changes in wave shape, which occur at a slow rate relative to wave speed. Slow shape changes accompanying soliton development significantly affect the breaking of oscillatory waves and provide plausible explanations for data on the breaking of solitary waves. An empirically and theoretically derived parameter of the form $H/(m^2L_o)$ describes breaker type and predicts the transition between waves which reflect and waves which break on a beach. (Author)

106. GALVIN, C., "Constraints on the Maximum Longshore Current Velocity," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Longshore currents, Wave theory, Extreme values*

The measurements are evidence that longshore current velocity has a maximum value. There are a surprising number of physical constraints that can explain such a maximum, five of which are listed here: (a) maximum lateral force, (b) refraction constraints, (c) erodible channel, (d) velocity distributions on fixed beds, and (e) wind. (DHL)

107. GALVIN, C.J., and EAGLESON, P.S., "Experimental Study of Longshore Currents on a Plane Beach," TM-10, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Jan. 1965.

Keywords: *Longshore currents, Theoretical model, Surf zone mass continuity, Laboratory experiments*

Measurements made of the characteristics of breaking waves and the resulting longshore currents for 34 combinations of wave height (up to 0.22 foot), period (0.40 to 1.50 seconds) and breaker angle (up to 32°) along a 20-foot test section of a 30-foot plane, smooth concrete beach with slope of 0.104. Observations and measurements show that most of the fluid in the surf zone stays there, and that longshore current velocity initially increases downstream from an obstacle. Velocity increases along the beach because the fluid forming the breaking wave has been withdrawn from the surf zone and thus *already* has a longshore component of motion of the breaking wave. A differential equation for this nonuniform flow agrees qualitatively with the measured variation of velocity with breaker angle and with distance from an obstacle. The nonuniformity of the flow was also indicated by the mean water level, which increased, and the breaker position and runup limit, which moved shoreward, downstream from the obstacle, but there is a possibility that these measurements were affected by the experimental apparatus. (Authors)

108. GALVIN, C.J., and NELSON, R.A., "Compilation of Longshore Current Data," MP 2-67, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Mar. 1967.

Keywords: *Longshore currents, Littoral processes, Ocean waves, Coastal engineering*

This report is a compilation of published longshore current data comprising 352 separate observations; 225 from 4 laboratory studies, and 127 from 4 field studies. Eight tables of data include measured longshore current velocity, wave direction, wave height, wave period, and beach slope. (Authors)

109. GALVIN, C.J., and SAVAGE, R.P., "Longshore Currents at Nags Head, North Carolina," *Bulletin of the Coastal Engineering Research Center,* Vol. II, U.S. Army, Corps of Engineers, Washington, D.C., 1965-66.

Keywords: *Longshore currents, Field investigations*

Longshore current velocity and associated wave and beach conditions were measured during 5 days in March 1964, along a beach on the Outer Banks of North Carolina. Velocity measurements, obtained by repeatedly timing the travel, over a 200-foot distance, of free-floating balloons filled with freshwater did not indicate a pulsating flow for the longshore current during the time of measurement and over the distance traveled by the floats. Breaker angle, the variable most closely correlated with current velocity, was measured by Brunton compass, by triangulation on a buoy at the breaker line, and by measurement of the velocities of the crest and plunge point of the breaking wave. Wave height and wave period were measured from wave gage records and by visual estimation. Beach slopes beneath the surf zone, measured from profiles supplied by the Louisiana State University field station at Nags Head, varied from 0.026 to 0.030. In four of the five sets of data obtained, the measured velocity (1.3 to 4.3 feet per second) differed by 0.1 to 1.0 foot per second from that predicted by two very different equations for longshore current velocity. (Authors)

110. GARCIA, C.S.V., "Bed Shear Stress Coefficient Within the Surf Zone," M.S. Thesis, U.S. Naval Postgraduate School, Monterey, Calif., 1977.

Keywords: *Surf zone, Boundary stress, Longshore current, Wave set-up, Wave theory*

An analytical formulation of the bed shear-stress coefficient inside the surf zone is derived using the concept of radiation stress. A truncated Rayleigh probability density function is used to describe the wave field inside the surf zone and provides the input to calculate the variation of wave energy and longshore current as a function of wave height, water depth, and distance to shore. The wave setup is approximated using a sinusoidal wave solution. Field measurements of longshore current and waves within the surf zone are used to calculate the bed shear stress. (DHL)

111. GERRITSEN, F., "Energy Dissipation in Breaking Waves," *Proceedings of the Fifth International Conference on Port and Ocean Engineering Under Arctic Conditions*, Norwegian Institute of Technology, University of Trondheim, Trondheim, Norway, Vol. 1, 1979, pp. 607-619.

Keywords: *Wave breaking, Surf zone, Field and laboratory studies*

Under prototype conditions the major causes of energy dissipation in waves are bottom friction and breaking. Both aspects are analyzed in this study. Experimental evidence shows that in a breaking wave regime the disturbance of the flow in waves is often limited to only the upper portion of the depth; a two- or three-layer model may then be used to describe the water motion. Field experiments have been carried out in a traverse at Ala Moana Park in Honolulu, from which wave spectra have been computed and energy losses have been calculated. In order to broaden the scope of measuring conditions, the field tests have been simulated by a hydraulic model on a 1:12 scale. (Author)

112. GODA, Y., "Irregular Wave Deformation in the Surf Zone," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 18, Dec. 1975, pp. 13-26.

Keywords: *Nearshore circulation, Numerical model, Laboratory and field experiments*

A theoretical model of irregular wave breaking and dissipation is developed. The setup of irregular waves is computed by means of radiation stress in association with the above wave breaking model. Amplitudes of surf beats are estimated with an empirical formula based on the wave observation near the shoreline. These three are combined to form a numerical model of wave deformation in the surf zone. The validity of the numerical model is confirmed by irregular wave experiments and field observation data. The results of the study are summarized with a method of wave height estimation in the surf zone. (DHL)

113. GOURLAY, M.R., "Wave Set-Up and Wave Generated Currents in the Lee of a Breakwater or Headland," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 3, 1974, pp. 1976-1995.

Keywords: *Longshore currents, Breakwater effects, Laboratory investigations, Wave setup*

Field and model observations indicate the existence of wave-generated currents in the lee of breakwaters and headlands. It is shown by an idealized laboratory experiment that such currents could be produced by an alongshore gradient of breaker height with wave crests parallel to the beach. The mechanism for the generation of the current is explained together with some of its characteristics including its interaction with the wave setup which causes it. It is further shown that it is possible to calculate by simple methods the hydraulic conditions causing the current.

Currents produced by this mechanism appear to be of practical importance in determining the local plan shapes of beaches close to breakwaters and headlands. (Author)

114. GOURLAY, M.R., "Non-Uniform Alongshore Currents," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 701-720.

Keywords: *Nearshore circulation, Breakwater diffraction, Laboratory experiments*

Alongshore gradients of breaker height have been shown to significantly influence the velocities and circulation patterns of nearshore current systems. Experimental data from an idealized laboratory experiment show that the form of the nonuniform wave-generated current system resulting from diffraction behind an offshore breakwater is essentially determined by the beach-breakwater geometry while its magnitude depends upon the wave height. Furthermore, the current may produce significant increases in the magnitude of the wave setup within the three-dimensional system. For the case investigated, where the alongshore gradient of breaker height is comparatively large, the maximum mean alongshore current velocity is not greatly affected by bottom resistance and may be computed for plunging breakers from a relation of the following form

$$\frac{V}{\sqrt{gH_b}+1} = f\left(\frac{H_b}{d_b}, \frac{x_p}{H_b}, \tan\alpha\right)$$

deriving from a simple momentum analysis including "radiation stress" terms. The influence of bottom resistance can be included if necessary. (Author)

115. GOURLAY, M.R., "Wave-Generated Currents," Ph.D. Dissertation, University of Queensland, St. Lucia, Queensland, Australia, 1978.

Keywords: *Nearshore circulation, Laboratory studies, Offshore breakwater*

A comprehensive investigation and review of literature has been made concerning the nature and characteristics of the wave-generated currents which cause littoral drift. The author is primarily concerned with nearshore circulations and nonuniform longshore currents generated on a beach behind an offshore breakwater. These flows result from diffraction behind the breakwater causing longshore gradients in breaking height since the waves approach normal to the plane beach. Gradients in wave setup result to drive the circulations. The analtyical approach employed essentially decouples the longshore and shore normal equations to derive analytical expressions for nonuniform longshore current and wave setup, respectively. These formulations are for steep and flat beaches and attempt to take into account the lateral gradients in the decoupled equations. The theory is tested by laboratory experiments designed for the idealized circulation system behind an offshore breakwater. Agreement is characterized as "good" for setup and reasonable for velocity distribution. Neglect of lateral mixing is cited as reason for scatter in the velocity data comparison. The theory is also tested against three actual field situations. The influence of longshore currents on sediment transport is also discussed.

116. GUZA, R.T., "Excitation of Edge Waves and Their Role in the Formation of Beach Cusps," Ph.D. Dissertation, University of California, San Diego, Calif., 1974.

Keywords: *Theoretical models, Edge wave excitation, Beach cusps*

It is shown theoretically that surface waves incident on a beach from deep water can excite edge waves. In particular, a monochromatic wave train normally incident and reflected on a beach of constant gentle slope is found to transfer energy to edge waves through a weak resonant interaction resulting from an instability of the incident wave with respect to perturbation by edge waves. The analysis is based on the shallow-water approximation and ignores the earth's rotation and consequently applies only to relatively low-mode, high-frequency waves. Coupling coefficients, frequencies, and longshore wave numbers of the excited waves are given. (Author)

117. GUZA, R.T., "Nonlinear Waves in the Surf Zone," *Proceedings of a Workshop on Coastal Sediment Transport*, University of Delaware, Dec. 1978, pp. 79-85.

Keywords: *Wave theory, Shoaling, Nonlinear effects, Surf zone*

Wave shoaling is an inherently nonlinear process resulting in a transfer of energy away from incident wave frequencies. Frequencies higher than the incident waves probably receive their energy via strong, but nonresonant, interactions. This transfer to high frequencies must enhance the overall wave velocity shear and dissipa-

tion, and may be intimately related to the onset of wave breaking. The energy transfer to low frequencies appears to be dominated by resonant excitation of long edge waves. (Author)

118. GUZA, R.T., and BOWEN, A.J., "The Resonant Instabilities of Long Waves Obliquely Incident on a Beach," *Journal of Geophysical Research*, Vol. 80, No. 33, Nov. 1975, pp. 4529-4534.

Keywords: *Edge waves, Resonance, Headland control, Standing waves, Beach cusps*

A monochromatic unidirectional wave train incident on a plane beach and strongly reflected there is shown to transfer energy to edge waves of lower frequency through a weak nonlinear interaction. For any angle of wave incidence the most readily excited edge wave perturbation consists of two low-mode progressive edge waves, generally with different frequencies and wave numbers, traveling in opposite directions along the beach. Standing edge waves, which might form stationary morphologic features with a regular longshore rhythm, are theoretically only excited when the primary surface waves are normally incident. However, edge waves generated by almost normally incident primary waves may be linked to features which slowly migrate alongshore. On beaches bounded by headlands or jetties the progressive edge waves excited would be reflected at both ends, forming a complex pattern of standing waves. For beaches bounded at one end, only one of the edge waves would be standing. Regular beach cusps would therefore be expected in the vicinity of barriers. These cusps should decrease in relief with increasing distance from the obstacle as the reflected edge wave, which is not being actively forced, dies away due to viscous dissipation and further nonlinear interactions. Intriguingly, the cusps should have slightly different wavelengths on either side of the obstacle. (Authors)

119. GUZA, R.T., and BOWEN, A.J., "Finite Amplitude Edge Waves," *Journal of Marine Research*, Vol. 34, No. 2, May 1976a, pp. 269-293

Keywords: *Edge waves, Standing waves, Resonance, Maximum amplitudes, Laboratory experiments*

Large-amplitude edge waves are shown to be modified by nonlinear effects in a way very similar to surface waves in deep water (Stokes, 1947); trapped harmonics tend to sharpen the wave crests and the natural frequency increases with wave amplitude, progressive edge wave propagating faster at large amplitude. A standing edge wave exhibits additional properties due to interaction between its two constituent progressive waves. Of particular interest, and the subject of laboratory experiments, is the observation that a standing edge wave, frequency σ, radiates energy at 2σ to the far field. This is a special example of the complete class of resonant interactions between edge waves trapped against a coastline and normal surface wave propagating from, or toward, deep water. (Authors).

120. GUZA, R.T., and BOWEN, A.J., "Resonant Interactions for Wave Breaking on a Beach," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976b, pp. 560-579.

Keywords: *Surf zone resonance, Theory, Laboratory experiments, Runup*

A laboratory and theoretical study of the transition from strongly reflected surging to dissipative plunging breakers on a relatively steep plane beach (1:8) has revealed the following: (a) The runup and offshore variation of sea surface elevation of surging waves are well predicted by linear theory. (b) The fluctuating part of the runup (related to the amplitude of the reflected incident wave) reaches a maximum value; a further increase in incident progressive wave energy results in increased dissipation. (c) Subharmonic edge waves (the growing instabilities of surging waves) are driven primarily by the swash motion, which does not increase with increasing incident breaking wave height. However, the turbulence accompanying incident wave breaking, and the effective eddy viscosity, rapidly increases with increasing breaker height. As a result, subharmonic resonances do not occur with spilling or steep plunging waves; very strong viscous effects suppress the nonlinear instabilities. (d) Edge waves generated by a surging incident wave can be suppressed by superimposing an additional breaking wave of different frequency on the incident wave field. Thus, any excited edge waves are likely to have length scales at least the order of a surf zone width. (Authors)

121. GUZA, R.T., and THORNTON, E.B., "Variability of Longshore Currents," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 756-775.

Keywords: *Longshore currents, Field experiments, Time variations*

Simultaneous measurements were made of the offshore directional spectra

of gravity waves, and longshore currents within the surf zone. The goal was to test theories which suggest a direct relationship between mean longshore currents ($\overline{V}$) in the surf zone and offshore values of the off-axis component of radiation stress (Sxy). Seventeen-minute averages of both Sxy and $\overline{V}$ showed considerable temporal variation and little or no tendency to vary together. There was also considerable longshore spatial variability of the longshore current. Attempts to measure gradients of Sxy in the surf zone failed because of small errors in instrument orientation. The measurements suggest that considerable temporal and spatial averaging will generally be required to obtain a representative picture of longshore currents, even if no rip currents are present, due to the presence of 'eddy" motions or long edge waves. (Authors)

122. GUZA, R.T., and THORNTON, E.B., "Local and Shoaled Comparisons of Sea Surface Elevations, Pressures, and Velocities," *Journal of Geophysical Research*, Vol. 85, No. C3, Mar. 1980a, pp. 1524-1530.

Keywords: *Field experiments, Surf zone elevations, Pressures, Velocities*

Sea surface elevations, or pressures, and velocities were measured at closely spaced (wavelength or less) locations in a line extending from 10-meter depth to inside the surf zone at Torrey Pines Beach, San Diego, California. Intercomparisons of local pressure, velocity, and sea surface elevation spectra for the wind wave frequencies (0.05-0.3 Hz) were made by using linear wave theory. Errors in both total variance and energy density in a particular frequency band are less than 20 percent both inside and outside the surf zone, except in the immediate vicinity of the breakpoint, where larger disparities are observed. Surface elevation spectra calculated at 10 meters were shoaled by using linear wave theory. The total variance of stations between 10- and 3-meter depth are typically predicted with less than 20 percent error, although harmonic amplification and other nonlinear effects can lead to significant errors in the prediction at particular frequency bands. Observations inside 3-meter depth significantly departed from the predictions of linear shoaling theory. (Authors)

123. GUZA, R.T., and THORNTON, E.B., "Longshore Currents in the Surf Zone," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980b.

Keywords: *Longshore currents, Field measurements, Temporal variability, Theory*

As part of the National Sediment Transport Study, an extensive series of measurements of nearshore and surf zone waves and currents was obtained during November 1978. The directional spectrum of waves propagating toward the coast was measured in 10-meter depth with a linear array of pressure sensors. Wave heights and currents were measured at many surf zone locations with surface piercing staffs and Marsh-McBirney electromagnetic current meters, respectively. The paper will discuss the relationship between incident waves and steady longshore currents. The measurements were compared to the theory of Longuet-Higgins (1970) by putting the measured offshore radiation stress into an "equivalent" monochromatic, unidirectional wave at the measured spectral peak. Temporal variabilities of longshore currents, and the averaging times necessary for a good estimate of the true mean, will also be considered. (Authors)

124. HAILS, J., and CARR, A., eds., *Nearshore Sediment Dynamics and Sedimentation*, 1st ed., John Wiley & Sons, Ltd., London, 1975.

Keywords: *Sediment transport, State-of-the-art*

This is an interdisciplinary review of papers by engineers, mathematicians, physicists, sedimentologists, physical oceanographers, and geomorphologists on recent developments in sediment and water mass movement in nearshore zone.

125. HALLERMEIER, R.J., and JAMES, W.R., "Development of a Shallow-Water Wave Direction Gage," *Proceedings of the International Symposium on Ocean Wave Measurement and Analysis*, American Society of Civil Engineers, Vol. 1, 1974, pp. 696-712.

Keywords: *Waves, Wave theory, Direction, Instrumentation*

This paper is a status report on an effort to develop a nearshore wave direction gage with a novel principle of operation. This point direction gage uses a thin pile in fairly shallow water to nonlinearly but regularly, transform each steep incident crest, momentarily forming a bow wave. A few water level gages deployed around the pile sense the bilaterally symmetric transformation, and then the symmetry direction of a data set from the gages is electronically estimated. Preliminary laboratory tests have indicated direction measurements of high precision may be made from a few data on peak water level at a pile.

Details of the envisioned instrument's operation are discussed. There is a variation in peak water level at the pile on the order of the incident crest velocity head, and the accuracy and resolution of the water level gages in sensing this variation seem to place the most important limitations on the instrument's usefulness: the direction of only rather energetic crests can be measured. Some specific design choices are given for a simple instrument that will be useful in typical Great Lakes wave action, according to available data. The remaining development work is clearly indicated; planned efforts will establish the capabilities of this type of instrument. (Authors)

126. HANSEN, J.B., and SVENDSEN, I.A., "Waves in Shoaling Water Experimental Results," *Euromech 102* (Breaking Waves: Surf and Run-up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Wave shoaling, Wave setdown, Laboratory experiments*

Two series of tests have been performed in a 60-centimeter-wide wave flume with a plane beach of slope 1:35 with a constant depth of water of 36 centimeters in front of the slope. The first series of tests covers the transformation of the waves up to the point of breaking, measuring wave heights, setdown, phase velocities at points 2 to 4 centimeters apart along the flume, and in addition wave profiles were recorded at some points. The aim was to compare with theoretical predictions for the wave characteristics, including the deformed wave profile. (DHL)

127. HANSEN, U.A., "Wave Setup and Design Water Level," *Journal of Waterway, Port, Coastal and Ocean Division*, Vol. 104, No. WW2, May 1978a, pp. 227-240.

Keywords: *Wave setup, Field measurements, Wave theory*

During the winter of 1975-76 measurements were made by the Leichtweiss-Institut of the Technical University of Braunschweig at the west coast of the island of Sylt in the North Sea. The purpose of the field investigations was to determine the wave-induced setup in the surf zone and on the beach, defined as the height difference between the mean water level (MWL) and the stillwater level (SWL) and the influence of typical offshore parameters on this phenomenon. A new scheme was defined to determine the MWL as the mean value of the water surface variations measured at incremental time intervals over a certain time span. The maximum setup on the beach can reach values up to 30 percent of the incident significant wave height. The field investigations have shown that the rise of the mean water level due to wave setup is significant and should be taken in account in determining the design water level for coastal structures. (Author)

128. HANSEN, U.A., "Wave Set-Up in the Surf Zone," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978b, pp. 1071-1084.

Keywords: *Wave setup, Field measurements, North Sea*

Field measurements were made at the west coast of the island of Sylt in the North Sea to determine wave setup. Based on 27 sets of measurements the maximum wave setup on the beach is estimated to be

$$\bar{\eta}_{max} \doteq 0.3\, H_{0,s}$$

where $H_{0,s}$ is the significant deepwater wave height and is in good agreement with the theory of Collins (1972) for irregular waves. In terms of the breaker height, wave setup can be expressed as

$$\bar{\eta}_{max} \doteq 0.5\, H_{B,s}$$

where $H_{B,s}$ is the significant wave height at the breakers.

129. HARRIS, D.L., and SAVAGE, R.P., "Surf Zone Wave Statistics," Research Project, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., 1978-1981

Keywords: *Surf zone, Field measurements, Statistical correlation*

This project determined the statistics of breakers in the surf zone, both at a point, and through the distance across the surf zone; to relate these surf statistics to statistics measured at a wave gage in deeper water, and the statistics obtained in deep water from wave observations or hindcasts; and to measure the modification of waves as they cross the surf zone. (Authors)

130. HARRIS, T.F.W., "A Qualitative Study of the Nearshore Circulation off a Natal Beach with a Submerged Longshore Sandbar," M.S. Thesis, University of Natal, Durban, South Africa, 1964.

Keywords: *Nearshore circulation, Field investigation*

Studies were made of the nearshore circulation off a beach on the Natal Coast, with a marked offshore submerged sandbar. Commonly, waves broke over the bar and re-formed before finally breaking at the shore. A qualitative description is given of the three main types of circulation patterns which depended on the degree of wave obliquity. With normal wave approach clean cut narrow rip currents characterized a cellular circulation. With oblique waves the current setup was almost wholly alongshore. (Author)

131. HARRIS, T.F.W., "Field and Model Studies of Nearshore Circulations," Ph.D. Dissertation, University of Natal, Durban, South Africa, 1967.

Keywords: *Nearshore circulation, Field and laboratory studies, South Africa*

Field and laboratory investigations of circulations, and currents induced by waves on the coast were made. Two main classes were identified, namely: a cellular circulation system resulting from near-normal wave propagation on the beach; and essentially longshore flow when oblique wave attack was observed. The theory applied was based on continuity of mass and solitary wave theory and not radiation stress theory. A mechanism for the transition from a cellular to longshore system is proposed.

132. HARRIS, T.F.W., "Nearshore Circulations: Field Observations and Experimental Investigations of an Underlying Cause in Wave Tanks," *Symposium on Coastal Engineering*, South African Council for Scientific and Industrial Research, Stellenbosch, South Africa, June 1969.

Keywords: *Nearshore circulation, Field experiments, Laboratory measurements*

Commonly occurring features of the Virginia Bay test site were the submerged offshore sandbar and trough, and consequently two zones of breakers, an outer one in the vicinity of the bar and an inner one near the foreshore. Using dye tracers it was found that there were two circulation systems, one associated with each zone. Experiments in wave tanks with generated waves breaking normally to fixed-bed plane beaches demonstrated that even under conditions of considerable uniformity the main features of the cellular nearshore circulation could well be simulated. (DHL)

133. HARRIS, T.F.W., et al., "Mixing in the Surf Zone," *International Conference on Water Pollution Research*, South African Council for Scientific and Industrial Research, 1962, pp. 177-198.

Keywords: *Surf zone, Turbulent mixing, Field experiments*

The investigations reported were designed to study the concentration changes with time and distance which a miscible liquid undergoes when discharged into the surf zone, and to gain some understanding of the mixing processes involved. The results of field experiments under conditions of normal and oblique wave approach on the Natal Coast as well as some wave tank studies are reported. Diffusion coefficients were between 180 and 700 square feet per minute. (Authors)

134. HARRISON, W., "Empirical Equation for Longshore Current Velocity," *Journal of Geophysical Research*, Vol. 73, No. 22, Nov. 1968, pp. 6929-6936.

Keywords: *Field studies, Mean longshore currents, Empirical*

Ninety-eight observations of longshore current velocity, beach slope, and the breaker height, period, angle, crest length, and trough depth were made on an Atlantic Ocean beach. Precision inshore surveys during the observation period revealed an essentially plane beach with an offshore bar parallel to the shoreline during two-thirds of the study period. Analysis of replicate measurements of current velocity revealed no topographically induced "nonuniformity" in the current and suggested that an individual determination of velocity was within about 10 percent of the true velocity value. A linear multiregression analysis performed on the data resulted in the following empirical correlation, for the four strongest independent variables: $\bar{V} = -0.170455 + 0.037376(\bar{\alpha}_b) + 0.031801(\bar{T}_b) + 0.241176(H_{bs}) + 0.030923(\bar{m})$ where $\bar{V}$ is in meters per second, $\bar{\alpha}_b$ is the mean acute angle between the breaker front and the shoreline in degree, $\bar{T}_b$ is in seconds, H_{bs} is the significant breaker height in meters, and $\bar{m}$ is the mean beach slope in degrees.

The total reduction of variation R^2 for $\bar{\alpha}_b$ is 0.46 and for $\bar{\alpha}_b$ plus $\bar{T}_b$ it is 0.53; H_{bs} and $\bar{m}$ each add 0.02 to successive values of R^2. The similarity between this equation and that obtained by Sonu, et al. (1967), who used similar variables and analytical techniques, suggests that a general equation of this type may be valid for many Atlantic beaches. The present equation may be applied to values of H_{bs}, $\bar{T}_b$ and $\bar{m}$ falling within certain specified ranges when $\bar{\alpha}_b$ falls between 2.0° and 15.0°. (Author)

135. HARRISON, W., and KRUMBEIN, W.C., "Interactions of the Beach-Ocean-Atmosphere System at Virginia Beach, Virginia," TM-7, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Dec. 1964.

Keywords: *Longshore currents, Regression analysis, Atmospheric parameters, Field measurements*

Field measurements of offshore data at Virginia Beach, Virginia, were used in multiregression analysis to predict mean longshore currents. Six variables T, H_o, tan β, onshore windspeed, offshore windspeed, and wave direction were the strongest factors accounting for current variability, their *relative* importance being in that order. The reason windspeed ranked ahead of wave direction (1 to 2 percent of variability) was felt due to wave refraction which controls wave breaking angle near shoreline which can be very different than *deepwater wave direction*.

136. HARRISON, W., PORE, N.A., and TUCK, D.R., Jr., "Predictor Equations for Beach Processes and Responses," *Journal of Geophysical Research*, Vol. 70, No. 24, Dec. 1965, pp. 6103-6109.

Keywords: *Coastal variables, Field measurements, Statistical correlations*

A stepwise (linear) multiple regression procedure is applied to 11 environmental variables (or predictors) in the beach-ocean-atmosphere system at Virginia Beach, Virginia, for the following five predictions: mean longshore current velocity, mean bottom slope in the shoaling wave zone, average mean grain size in the shoaling wave zone, and beach deposition and beach erosion on the lower foreshore. Predictors consist of variables related to beach geometry, local water properties, local wind conditions, tidal fluctuations, and wave characteristics. The resultant equations are tested against a set of independent data and, with one exception, agree reasonably. It is believed that if the data set were increased to include at least 1 year's continuous measurements, the procedure outline would yield valid equations for all but stormy weather conditions. It is presupposed that some provision will have to be made for preconditioning the data, as 'storm' and 'nonstorm' data will probably have to be analyzed separately. (Authors)

137. HARRISON, W., et al., "A Time Series From the Beach Environment," Environmental Science Services Administration Technical Memorandum No. 1, Land and Sea Interactions Laboratory, Norfolk, Va., 1968.

Keywords: *Coastal variables, Field measurements, Statistical*

A continuous, 26-day series of measurements taken at Virginia Beach, Virginia (August to September 1966), along 16 stations included breaker angle, breaker height and period, and velocity of longshore current among the more than 20 physical parameters cited; time series were prepared from the 4 to 6 measurements each day, and smooth interpolation curves fitted by eye to permit 1-hour intervals to be digitized. Nine independent variables were used to describe the change in sediment volume on the foreshore over a single tidal cycle.

138. HAUGUEL, A., "Adaptation of Tidal Numerical Models to Shallow Water Wave Problems," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980, pp. 277-278.

Keywords: *Nearshore circulation, Numerical model, Boussinesq equations*

The unsteady, long wave equations are extended to include vertical accelerations present in short, wind-induced waves near the coast. The conservation form equations in two dimensions are different than those employed by Abbott, et al. (1978). A numerical integration scheme based upon the finite-difference method is discussed. It requires extreme care to reduce the numerical amplitude and phase errors present. Some initial applications to wave diffraction around a jetty are shown.

139. HIBBERD, S., "Approximations to Shoreward Bore Travel and Run-Up," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Surf zone, Bore propagation, Theoretical*

A new formulation involving evaluating the bore variables strictly along the bore path leads to a description of shoreward bore travel that includes these rearward accelerations. This analysis leads naturally to an extension of the Whitham approximation that can be applied to a class of incident wave shapes while maintaining the same degree of accuracy as expected from the Whitham approximation in describing an incident uniform bore. An exact solution for the runup and backwash is obtained

from a characteristic formulation of the flow for a particular wave profile specified at the seaward edge of the beach. The exact solution is then extended, using the above approximation to the bore variable, to determine analytically the net of receding characteristics originating from the bore path. (DHL)

140. HIBBERD, S., and PEREGRINE, D.H., "Comparisons of Experimentally Generated Surf with Theoretical Model," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Surf zone, Breaking waves, Laboratory experiments, Surf theory*

Comparisons have been made of theoretical solutions against experimental observations in order to determine the applicability of the inviscid model and to understand the contributing effects of friction in the real fluid situation. Experimental measurements were performed by Hansen and Svendsen (1977) using experimental facilities as described by Svendsen and Hansen (1976). The first wave height recorder was positioned beyond the area where waves, other than the first few, break and in the area where they have developed a fully turbulent head. Other wave height recorders were positioned at various intervals shoreward. (DHL)

141. HIBBERD, S., and PEREGRINE, D.H., "Surf and Run-Up, in Waves on water of Variable Depth," *Proceedings of the Symposium of the Australian Academy of Science*, Canberra, Australia, 1977, pp. 114-117.

Keywords: *Surf zone, Breaking waves, Bore theory, Backwash*

There is usually a region on beaches, closer to the shore than the area in which waves first break, in which the waves may be modeled by a combination of the finite-amplitude shallow-water equations and bores. Numerical computations of such bores and their runup have been performed and compared with analytical results. Calculations for a single bore show the runup, rundown, formation of a backwash bore, and reflected waves propagating away from the shoreline. A preliminary calculation with periodic bores is shown. (Authors)

142. HIGGINS, A.L., SEYMOUR, R.J., and PAWKA, S.S., "A Compact Representation of Ocean Wave Directionality," *Applied Ocean Research*, Sept. 1980.

Keywords: *Instrumentation, Radiation stresses, Slope array meter*

The spectrum of the longshore component of shoreward-directed momentum flux (S_{xy}) due to ocean waves, taken with the energy spectrum for the same wave field, is shown to provide a compact and useful representation of ocean wave directionality. Records of orthogonal surface slope components are demonstrated to yield an unbiased estimate of S_{xy}. One method for estimation of S_{xy} using this relationship is investigated. Error analysis provides means for optimal selection of measurement parameters. Experimental verification is provided from laboratory tests and from field comparison with a five-element linear array. (Authors)

143. HINO, M., "Theory on Formation of Rip-Current and Cuspidal Coast," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, 1974, pp. 901-919.

Keywords: *Nearshore circulation, Rip currents, Theoretical model, Field observations*

The hydrodynamic instability theory is developed on the formation of rip current and cuspidal coast. The most preferred wavelength is shown to be about four times the distance from the shore to the breaker zone. Typical patterns of flow field and bottom configurations are represented. Finally, the theory is compared with field observations. (Author)

144. HINO, M., "Rip-Current and Coastal Topography," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1976, pp. 1326-1341.

Keywords: *Rip currents, Wave theory, Bottom topography*

At the 1974 Conference on Coastal Engineering (Copenhagen), the writer proposed a new theory on the mechanism of generation of rip current and cuspidal coast that the alongshore homogeneous structure of wave field and movable sedimental bottom (that is two-dimensional wave setup and bottom topography) is unstable to a small perturbation, the motive force of instability being the radiation stresses caused by incident wave. (Author)

145. HINO, M., and HAYASHI, N., "A Theory of Rip Current Generation," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 16, Dec. 1973, pp. 55-60.

Keywords: *Nearshore circulation, Rip currents, Wave theory, Stability*

The paper presents the instability theory for formation or nearshore circulation cells and rip current spacing. It is based on a small perturbation analysis of the time-averaged continuity and motion equations that include the radiation stresses to account for the momentum thrust of the waves. The fluid system is considered quasi-stationary relative to a very slowly varying bottom topography. This mechanism could be considered as a "free" oscillation theory in contrast to the "forced" deformation theory of Bowen (1969) for standing edge waves.

146. HOGG, N. G., "Longshore Current Generation by Obliquely Incident Internal Waves," *Geophysical Fluid Dynamics*, London, England, Vol. 2, No. 4, Sept. 1971, pp. 361-376.

Keywords: *Longshore current, Theoretical model, Radiation stresses, Internal gravity waves*

It is shown that a significant longshore current of maximum amplitude $\bar{V} = (3x10^{4}/v)$ centimeters per second (for typical oceanic values) can be forced between the breaker zone and shore by internal gravity waves obliquely incident on a plane beach. In the mean longshore momentum balance Reynolds stress terms appear which can be calculated to $O(\alpha)$, α being a bottom slope parameter, using a WKB approach. With appropriate assumptions being made about the amplitude behavior of the motion after breaking, the divergence of these stresses does not vanish and forces a current whose magnitude is determined by a balance with viscous stress derived from vertical eddy motions. (Author)

147. HORIKAWA, K., "Nearshore Currents," *Coastal Engineering: An Introduction to Ocean Engineering*, 1st ed., John Wiley and Sons, Inc., New York, 1978, pp. 185-230.

Keywords: *Longshore currents, Nearshore circulation, State-of-the-art*

Emphasis is on results reported in Japanese literature and not familiar to outside researchers. Chapter 4, Nearshore Currents, gives excellent summary of current state-of-the-art including tidal, wave-induced, and wind-driven currents nearshore. Author presents main results, equations while omitting complete derivations. Topics include: physical description of nearshore currents and circulation; radiation stress; a table of longshore mean current velocity formulas; wave setup and setdown; velocity distribution formulas of (1) Bowen, (2) Longuet-Higgins, (3) Thornton; rip currents; rip current model of Arthur; nearshore current system model and finally; a review of the field observations of Sonu and Sasaki. [Chapter 3 contains brief discussion of edge waves (p. 182-183)]. An excellent reference list for Chapter 4 is given (pp. 378-380). The book was published in 1978 and lists references up to 1974 (14th) Coastal Conference except Japanese literature of author and colleagues for 1976 and 1977.

In going through Chapter 4 it is clear that the author summarizes most of the current knowledge but does not editorialize as to what is best or what research is needed in the future.

148. HORIKAWA, K., "Nearshore Current Treatments and Their Application to Engineering Problems," *Proceedings of the Fourth International Conference on Port and Ocean Engineering Under Arctic Conditions*, POAC 77, University of Newfoundland, St. Johns, Vol. 1, 1978b, pp. 84-114.

Keywords: *Longshore currents, Nearshore circulation, State-of-the-art*

Five years have passed since the review of recent progress in the study of longshore currents by Longuet-Higgins. This paper reviews recent work on nearshore currents performed mainly by the Coastal Engineering Research Group at the University of Tokyo, and discussed briefly their engineering significance. Discussed are: field observation techniques, pattern of nearshore currents, numerical models for engineering use, and engineering applications. (DHL)

149. HORIKAWA, K., and ISOBE, M., "Dynamic Characteristics of Waves and Wave Induced Currents in Nearshore Area," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Nearshore circulations, Wave theory, Laboratory and field experiments, State-of-the-art*

The writer's main efforts devoted in this paper are to investigate quantitatively the applicability of the formulas or assumptions which have been commonly used for evaluating the numerous quantities such as wave height, wave celerity, and radiation stresses in the nearshore area. In order to accomplish the above purposes, the writers have done a series of laboratory investigations as well as field observations during the last 2 years. As a conclusion of the present studies, it can be said that the previous treatments based on the linear wave theory seem to be fairly well in general to grasp the general dynamic characteristics of wave and wave-induced currents in the nearshore area. (Authors)

150. HORIKAWA, S., and SASAKI, T., "Some Studies on Longshore Current Velocity," *Proceedings of the Conference on Coastal Engineering in Japan*, No. 15, 1968, pp. 126-135 (in Japanese, translated by Henry Oh, U.S. Army Topographic Command, Washington, D.C., Nov. 1971).

Keywords: *Longshore currents, State-of-the-art*

Literature is critically reviewed and summarized up through 1967 including Japanese and Russian efforts. Model laboratory tests conducted with movable-bed and irregular topography using submerged float to measure longshore current. Some fixed-bed model tests also conducted using Iwabana Harbor topography. Results were well below predicted values using the Galvin-Eagleson (1964) formula and it is suggested that the more complicated bathymetry requires formulations such as that of Shadrin (1961). No quantitative comparison of model and theory is given to draw conclusions. The influence of the Reynolds number on bottom friction coefficients is also discussed.

151. HORIKAWA, K., and SASAKI, T., "Field Observations of Nearshore Current System," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 15, Dec. 1972, pp. 133-125 (also *Proceedings of the 13th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1972, pp. 635-652).

Keywords: *Nearshore circulation, Measurement systems, Instrumentation, Field observations*

The two systems based on the principle of photogrammetric surveying have been developed to accomplish the field observations of nearshore current system induced by waves, and were applied to the field investigations on the Shonan Coast, Kanagawa Prefecture, Japan (Horikawa, et al., 1970). The first is called as the Balloon Camera System and the other is the Synchronized Helicopter System. The main efforts were concentrated to the simultaneous observations of waves and current fields in and out of the surf zone. Even then there still exist some difficulties to be overcome in applying the present systems, the validity and usefulness of these systems were demonstrated by the obtained data. In this paper are presented the details of the developed systems and a part of the analyzed results by using the data obtained in the field. (Authors)

152. HORIKAWA, K., LIN, M-C., and SASAKI, T.O., "Mixing of Heated Water Discharged in the Surf Zone," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 3, 1978, pp. 2563-2583.

Keywords: *Surf zone, Mixing processes, Field experiments, Dispersion coefficients*

In this paper, a description is given on the mixing processes of heated water discharged into the surf zone, based on the field investigations. In accordance with the flow characteristics observed, the flow region can be classified into three parts, namely the jet flow region, nearshore current region, and coastal current region. In the jet flow region, the flow characteristics are expressed well by the two-dimensional turbulent jet flow model and strongly influenced by the cuspate bottom configuration formed under the interaction between the jet flow and nearshore currents. It is realized that the decay of plume centerline temperature is slower than the other cases owing to the influence of bottom slope, water depth, and the direction of jet axis. By the dye tracer studies, in the nearshore current region the variance increases approximately with time at a power of 1.72 for longitudinal and of 1.95 for lateral, respectively, while the diffusion coefficient increases with diffusion scale at a power of 1.43 for longitudinal and of 1.71 for lateral, respectively. In the coastal current region, the representative isotherms are mainly in appearance either of the southerly alongshore or northerly stretch, possibly caused by some fairly long period waves.

The cloud of heated water was always confined within a certain strip of nearshore zone, likely in response to the existence of a turbulent boundary layer phenomena appeared in parallel to the coastline. Quantitative modeling of this resulting plume is then made. In addition, some pulsation patterns of isotherms were also observed. Finally, a graphical representation of the functional relationship between the relative temperature difference and the area within the specified isotherm is shown. (Authors)

153. HSU, S.A., "Wind Stress on a Coastal Water Surface," *Proceedings of the 13th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 3, 1972, pp. 2521-2532.

Keywords: *Nearshore currents, Wind surface stress, Field studies*

Simultaneous measurements of horizontal wind velocity above the water surface, air and water temperature difference, and water level were made

during the summer of 1971 at an exposed field site off the northwest coast of Florida. Three identical vertical arrays of six-cup anemometers were used; they were located in the surf zone, in the area between the inner and the outer bars, and on the outer slope of the outer bar. The distances of these three stations from the mean shoreline were approximately 30, 130, and 230 meters. Mean water depths were 1.5, 4.3, and 5.0 meters.

Analysis of the profile data under adiabatic and onshore wind conditions indicates that better than 90 percent of the valid wind profile measurements are logarithmic. It was found from the nearly 1,500 15-minute logarithmic wind profiles that the shear velocity U_* was not a linear function of windspeed, as is usually assumed in coastal applications, but had a functional relationship with velocity at 10 m or U_{10m} (from 0.5 to 8.5 meters per second), such that $U_* = 0.37\ U_{10m}^{2/3}$.

Comparison with similar investigations in deeper water and oceanic regions was also made. (Author)

154. HUDSON, R.Y., et al., "Coastal Hydraulic Models," SR-5, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., May 1979.

Keywords: *Beach erosion, Harbors, Hydraulic models, Inlets, Movable-bed models*

This comprehensive report describes the use of hydraulic models to assist in the solution of complex coastal engineering problems. The report provides information for use by both the laboratory research engineer and the field design engineer on the capabilities and limitations of coastal hydraulic modeling procedures. Surprisingly, no mention is made of laboratory scale models of longshore currents.

155. HUNTLEY, D.A., "Lateral and Bottom Forces on Longshore Currents," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976a, pp. 645-659.

Keywords: *Boundary shear stresses, Longshore currents, Instruments, Unsteady velocity field, Field experiments*

A two-component electromagnetic flowmeter has been used on a natural beach of slope 0.01 to measure mean longshore currents and the horizontal fluctuating velocities in the frequency range 0 to 1 hertz measurements extend up to 120 meters offshore and span about one-third of a wide surf zone. The cross product of the fluctuating horizontal velocities, assumed to contain the combined effects of radiation and Reynolds stresses, is plotted as a function of distance from the shoreline. The onshore-offshore gradient of the cross product is then equated with a bottom friction term either in the form used by Bowen (1969a) or in a form similar to that used by Longuet-Higgins (1970). The apparent values of bottom friction coefficient obtained in this way are at least a factor of two smaller than expected for Reynolds numbers and bottom roughness appropriate to the beach. Attempts to separate the radiation stress and the Reynolds stress contributions to the total stress term using cospectra fail to show distinguishable Reynolds stress contributions. Although this may be construed as being consistent with Battjes' (1975) beach slope dependent form for horizontal eddy viscosity rather than Longuet-Higgins' (1970) form it is argue that, in fact, the significant horizontal turbulence was not measured at all but was confined to a surface layer above the flowmeter. This leads to the hypothesis that lateral friction, as a surface boundary layer, and the bottom friction act on a less turbulent central layer, and that the small measured friction coefficient in the present experiment is the result of the combined effects of these layers. (Author)

156. HUNTLEY, D.A., "Long Period Waves on a Natural Beach," *Journal of Geophysical Research*, Vol. 81, No. 36, Dec. 1976b, pp. 6441-6449.

Keywords: *Longshore currents, Onshore-offshore currents, Field experiments, Spectral analysis*

A field experiment is described in which three two component electromagnetic flowmeters were used to measure simultaneously the longshore (v) and onshore-offshore (u) velocity components along a line normal to the shoreline and up to 100 meters offshore. Spectral analysis of the data from this experiment reveals the presence of a set of discrete spectral peaks of low frequency (0.014 to 0.05 hertz) which dominate over the wind wave peak close to the shoreline and which decay in amplitude with distance from the shore. The amplitudes of the velocity components for each of the four lowest frequency (and clearest) peaks have been plotted against distance from the shoreline and are found to compare satisfactorily with the calculated edge wave amplitude for the beach. Phases between u,v at one flowmeter and between u,u at difference distances offshore have also been found from cross spectra and confirm that the peaks are due to edge waves. It is suggested that each of these low-

frequency peaks corresponds to a progressive edge wave mode at the cutoff frequency for the beach. Ball (1967) and Guza and Inman (1975) calculate that the cutoff frequency ν for an edge wave of mode n should be proportional to $[n(n+1)]^{\frac{1}{2}}$, where the constant of proportionality is dependent on the subaqueous beach profile. The frequencies of the four lowest modes of cutoff edge waves (n=1,...,4), and the observed offshore decay of amplitude at each frequency indicates that assigning peaks to these modes is correct. Energy exchange between these cutoff modes, through nonlinear interaction is also suggested. The significance of observing progressive edge waves on this beach is briefly discussed. (Author)

157. HUNTLEY, D.A., and BOWEN, A.J., "Field Measurements of Nearshore Velocities," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974, pp. 538-557.

Keywords: *Surf zone velocities, Instrumentation, Measurement systems*

Two-component electromagnetic flowmeters are being used as the basis of an apparatus to measure nearshore velocities on natural beaches. The flowmeters are mounted on free-standing tripods, 1 meter base side and 0.3 meter high, to measure the two components of horizontal flow, and have been used in depths of up to 4 meters and up to 150 meters from the shoreline. The apparatus have proved both flexible and reliable on beaches ranging from steep shingle (slope =0.13) to very shallow sand (slope =0.01) and under a wide variety of wave conditions, including full storm waves on a beach of intermediate slope (0.04).

Results show that a single flowmeter can be used on a tidal beach to measure the variation of the flow field along a line perpendicular to the shoreline. In this way edge waves and steaq, nearshore circulation patterns have been detected. If several flowmeters are placed on a line perpendicular to the shoreline, the progress of individual waves can be followed as they pass over each flowmeter in turn, and hence propagation speeds, changes of waveform, and the development of lower frequency wave motion close to the shoreline can be studied. (Authors)

158. HUNTLEY, D.A., and BOWEN, A.J., "Comparison of the Hydrodynamics of Steep and Shallow Beaches," *Nearshore Sediment Dynamics and Sedimentation*, J. Hails and A. Carr, eds., John Wiley & Sons, Inc., New York, 1975a, pp. 69-109.

Keywords: *Surf zone hydrodynamics, Time variations*

A first step toward understanding the complexities of nearshore sediment dynamics must be to study the nearshore motion of the water itself, and this is the aim of the present research program. Beaches of widely difference slopes have been studied and, in particular, a steep (slope 0.13) shingle beach and a shallow (slope 0.014) sand beach have produced results of considerable interest.

This paper describes times series for the two horizontal components of water velocity, measured at different distances from the shoreline on the two beaches, and discusses the probability distributions of the velocities, the mean current patterns close to the shore and the frequency dependence of the wave energy.

The hydrodynamics of the steep and shallow beaches differ widely. In particular, periodic longshore variations of the nearshore velocity field were observed on the steep beach but not on the shallow beach. On the steep beach, edge waves with a period twice that of the incident waves and with a longshore wavelength of 32 meters were observed and it is suggested that swash interaction in the narrow surf zone was responsible for generating these waves. The mean flow field on other occasions also revealed the existence of nearshore circulation cells on the steep beach. On the shallow beach, on the other hand, no short period edge waves were observed and the measured mean flow was a steady longshore current generated by obliquely incident waves. (Authors)

159. HUNTLEY, D.A., and BOWEN, A.J., "Field Observations of Edge Waves and Their Effect on Beach Material," *Journal of the Geological Society of London*, London, England, Vol. 131, Pt. 1, Jan. 1975b, pp. 69-81.

Keywords: *Edge waves, Field measurements, Surf zone particle velocities, Cusps*

Observations of wave motion are described particularly of the horizontal particle velocities, up to a maximum of 25 meters from the shoreline on Slapton Beach, Start Bay. For the first time on a natural beach, the observed velocities reveal directly the presence of short period edge waves, modes of wave motion trapped to the shoreline by refraction. These edge waves occurred at the first subharmonic ($\sigma/2$) of the incident wave frequency σ, and their exponential decay in amplitude with distance from the shoreline was consistent with edge waves of mode number zero with a longshore wavelength of 34±6 meters. The implications of these observations are discussed in the light of recent

laboratory experiments, and theories of edge wave generating subharmonic wave motion on Slapton beach are described.

A steady longshore current prevented these subharmonic edge waves from forming cuspate or crescentic features in the nearshore beach material. Small shoreline cusps observed on Slapton beach on other occasions were consistent with edge waves at the frequency of the incident waves themselves. (Authors)

160. HUNTLEY, D.A., and BOWEN, A.J., "Beach Cusps and Edge Waves," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1978, pp. 1378-1393.

Keywords: *Edge waves, Beach cusps, Field measurements*

Beach cusps are very common, concave-seaward cuspate patterns at the shoreline of a beach, which tend to occur with a regular longshore spacing, but which can have a wide range of longshore wavelengths from a few centimeters to several kilometers or more. Edge waves, resonant waves trapped at the shoreline by refraction, have been suggested as the cause of beach cusps but it has proved difficult to establish a definitive link on natural beaches. This paper describes field measurements of nearshore velocities, in all three orthogonal directions, that show the pressure of edge wave motion just before the formation of beach cusps of the corresponding wavelength, and thus provides convincing evidence that edge waves are responsible for beach cusps. The magnitude of the observed edge wave oscillatory and drift velocities are found to be large and apparently well able to form cusps of the observed size. The observed edge waves are at the subharmonic of the incident wave frequency and thus are the field equivalent of the laboratory observations of Guza and Inman (1975) and Guza and Bowen (1977). It is not clear, however, whether the developing cusp topography enhanced or suppressed the edge wave motion. (Authors)

161. HWANG, L.S., "Wave Set-Up of Nonperiodic Wave Train and Its Associated Shelf Oscillation," *Journal of Geophysical Research*, Vol. 75, No. 21, July 1970, pp. 4121-4130.

Keywords: *Wave setup, Laboratory experiments, Irregular waves*

A set of experiments has been performed to measure the wave setup of a nonperiodic wave train. Detailed features of the wave setup resulting from the wave train are discussed and compared with field results. Shelf oscillations resulting from the wave setup of a nonperiodic wave train were also investigated; such oscillations are entirely related to the geometry of the shelf. Wave setup has been observed for both breaking and nonbreaking waves. (Author)

162. HWANG, L-S., and DIVOKY, D., "Breaking Wave Setup and Decay on Gentle Slopes," *Proceedings of the 12th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1970, pp. 377-389.

Keywords: *Wave setdown, Wave setup, Wave theory*

Waves of large amplitude on a gentle slope may form spilling breakers which propagate shoreward and are slowly transformed. In addition, there occurs a modification of the mean water level termed wave setup. An analytical description based upon consideration of momentum flux has been developed which predicts this wave setup and the decay history of breaking wave height. The results have been compared with experiments and found quite satisfactory. The effect of wave setup on breaking wave transformation is particularly important near the shoreline, where setup dominates the vanishing mean depth. (Authors)

163. IJIMA, T., MATSUO, T., and KOGA, K., "Equilibrium Range Spectra in Shoaling Water," *Proceedings of the 12th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1970, pp. 137-149.

Keywords: *Surf zone, Spectral theory*

In shoaling water on sloping beach, waves break by hydraulic instability due to the finiteness of water depth, so that frequency spectra of waves in surf zone must have any limiting form similar to the equilibrium spectrum given by Phillips (1958). In this paper, authors have derived an equilibrium form of spectra for surf waves from the limiting wave condition at constant water depth by Miche (1944) and from breaking wave experiments on sloped bottom by Iversen (1952). The results are compared with surf wave spectra obtained from field observations by means of stereo type wave meter devised by the authors (1968).

By means of this spectrum and by deepwater wave spectra for various wind conditions, significant wave heights and optimum periods of limiting waves in surf zone are calculated. (Authors)

164. INGLE, J.C., Jr., *The Movement of Beach Sand*, Elsevier Publishing Company, Amsterdam, 1966.

Keywords: *Sediment transport, Longshore currents, Field experiments*

An 18-month program of sand tracing using fluorescent tracers was conducted on five Southern California beaches in 1961-62. This book describes the detailed description and results of that study primarily concerned with littoral drift. Correlations of sand transport rates with wave and sediment parameters were inconclusive. A limited number of longshore current measurements were made using fluorescein dye. Measurements (3-5) across the surf zone at 50-foot intervals gave some indication of the resulting longshore velocity profile. Average currents were 1.0 foot per second and a maximum of 4.2 feet per second was recorded. Currents measured seaward of the breakers never exceeded 1.0 foot per second. It was said that the positive relationship between longshore current, angle of wave incidence, and breaker height as determined in the laboratory (Galvin, 1963) was substantiated by these field experiments. Correlations of longshore current and wave characteristics were inconclusive but did reveal that maximum currents often occurred midway between the breaker line and the swash zone.

165. INMAN, D.L., "Mixing in the Nearshore Zone," *Transactions of the American Geophysical Union*, Vol. 49, No. 1, Mar. 1968, p. 190.

Keywords: *Nearshore circulation, Turbulent mixing, Dye concentration, Theoretical models*

The rate of mixing in nearshore waters is determined by the spacing between rip currents and by the budget of water in the nearshore circulation cell. The budget consists of the onshore discharge of water by waves between rip currents (Q_f), the longshore discharge of water from cell to cell (Q_ℓ), and the seaward return of the flow through the surf zone by the rip current (Q_r). One model for Q_ℓ constant along the beach gives the concentration of dye N(n) for the n^{th} cell down current from a continuously injected source of dye as $N(n)/N_0 = [Q_\ell/(Q_\ell + Q_f)]^n$ where N_0 is the concentration leaving the injection cell. This and other models based on the advection terms for the nearshore circulation cell are shown to give reasonable predictions for concentrations of dye along beaches. (Author)

166. INMAN, D.L., and QUINN, W.H., "Currents in the Surf Zone," *Proceedings of the Second Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1951, pp. 24-36.

Keywords: *Longshore currents, Field measurements, Onshore-offshore current models, Momentum conservation*

Surface and bottom currents in the surf zone were measured at 15 equally spaced points along two straight beaches with approximately parallel bottom contours. The measurements showed that offshore currents predominate over onshore currents at the bottom, while at the surface there is a slight predominance in the onshore direction. With regard to the longshore component, it was found that surface and bottom currents have a similar velocity distribution. The variability of the longshore component as measured by its standard deviation is equal to or larger than the mean longshore velocity. This wide variation in longshore currents indicates the impracticability of estimating the mean velocity from a single observation of longshore current.

It was found that the momentum approach to the prediction of longshore currents by Putnam, Munk, and Traylor (1949) leads to useful forecasts provided the beach friction coefficient, k is permitted to vary with longshore velocity, V. The indicated relation is $k \sim V^{-3/2}$. (Authors)

167. INMAN, D.L., TAIT, R.J., and NORDSTROM, C.E., "Mixing in the Surf Zone," *Journal of Geophysical Research*, Vol. 76, No. 15, May 1970, pp. 3943-3514.

Keywords: *Nearshore circulation, Turbulent mixing, Mechanisms, Theoretical models, Eddy viscosity coefficients*

Two important mixing mechanisms are operative within the surf zone each having distinctive length and time scales determined by the intensity of the waves and dimensions of the surf zone. The first is associated with the breaking wave and its bore which produce rapid mixing in an onshore-offshore direction. This mixing, when normalized and averaged over the surf zone width X_b, gives coefficients of eddy diffusivity of the order of $H_b X_b/T$ where H_b and T are the breaker height and the period of the waves. The second process is advective and is associated with the longshore and rip current systems in the nearshore circulation cell. For constant longshore discharge of water between cells Q_ℓ, this process gives a concentration N_n, in the n^{th} cell downcurrent from a continuously injected source of dye of $N_n = N_0(Q_\ell/Q_m)^n$ is the concentration

leaving the injection cell, and Q_m is the maximum longshore discharge within a cell. As an approximation, the concentration decreases exponentially with distance y from the injection point when n is replaced by y/Y where Y is the spacing between rip currents. This relation gives an apparent longshore eddy mixing coefficient of the order of $Y\langle V_l \rangle$ where $\langle V_l \rangle$ is the longshore current velocity. Along ocean beaches $H_b X_b/T$ and $Y\langle V_l \rangle$ are about 10 and 100 square meters per second, respectively. (Authors)

168. IWAGAKI, Y., and SAKAI, T., "Representation of Water Velocity of Breaking Waves on Beaches by Dean's Stream Function," *Memoirs of the Faculty of Engineering*, Kyoto University, Kyoto, Japan, Vol. 38, No. 1, Jan. 1976, pp. 11-20.

Keywords: *Wave theory, Breaking waves, Stream-function theory*

Experimental values of water particle velocity of breaking waves on uniformly sloping beaches differ considerably from the theoretical values of Stokes waves of the third order and cnoidal waves of the second approixmation. In this paper, Dean's stream functions are calculated by giving simultaneously measured time variations of the water level of the breaking waves. Vertical distributions of horizontal water particle velocity at the crest phase, calculated by using these stream functions, are compared with experimental distributions in order to discuss the applicability of Deans's stream-function method. (DHL)

169. IWATA, N., "A Note on the Wave Set Up, Longshore Currents and Undertows," *Journal of the Oceanographic Society of Japan*, Tokyo, Japan, Vol. 26, No. 2, Aug. 1970, pp. 233-236.

Keywords: *Longshore currents, Wave setup, Rip currents, Theory*

This is an early effort to apply radiation stress principles to derive theoretical relations for wave setup for normal wave incidence and mean longshore current under oblique wave attack. Some comparisons attempted with empirical longshore current formulas and limited field data.

170. IWATA, N., "Rip Current Spacing," *Journal of the Oceanographic Society of Japan*, Tokyo, Japan, Vol. 32, No. 1, Oct. 1976, pp. 1-10.

Keywords: *Rip currents, Wave theory, Spacing*

Mass, momentum and energy conservation laws, including radiation stress, are used to derive an equation of the eigenvalues of rip current spacing.

A coastal region with a linear bottom slope is divided into two parts: an offshore region and a surf zone separated by the breaker line. Wave setup, wave energy, and mean current are assumed to be composed of a basic state, which is a function of the distance from the coast to the offshore region only, and of superposed two-dimensional perturbations.

In the case of normal incidence waves, the basic steady current system vanishes and perturbations are found to be of cellular shape. According to the boundary conditions at the coast, the stream function of perturbed motion in the surf zone can be represented by the confluent hypergeometric function; in the offshore zone it is approximated by the modified Bessel function.

Interpolation of the stream functions in the surf and offshore regions enables us to obtain a characteristic relation which gives the eigenvalues of the dimensionless alongshore spacing of rip currents systems as a function of a parameter determined by the bottom friction coefficient, width of the surf zone and breaker height. (Author)

171. IWATA, N., "Rip Current Spacing as an Eigenvalue," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 828-840.

Keywords: *Rip currents, Wave theory, Instability analysis*

Mass, momentum, and wave action conservation laws, including the radiation stress, are used to obtain a rip current spacing as an eingenvalue. A coastal region is divided into two parts: offshore region and surf zone separated by a breaker line. Only the case of normal incidence of the waves is considered. From the matching conditions of the two horizontal velocity components at the breaker line, rip current spacing is obtained as a function of a dimensionless parameter characterizing the surf zone, for an arbitrary value of a parameter indicating the strength of horizontal mixing. (Author)

172. JAMES, I.D., "Some Nearshore Effects of Ocean Waves," Ph.D. Thesis, No. 8258, University of Cambridge, Cambridge, England, 1972.

Keywords: *Longshore currents, Radiation stress theory, Nonlinear waves*

The author used nonlinear wave theory in classical radiation stress approach to derive longshore current profile. The difference in results for both wave setup and longshore currents in surf zone compared with linear theory are much less than one order of magnitude. This is said to provide some justification for use of simpler analytical results from the linear theory.

173. JAMES, I.D., "Non-linear Waves in the Nearshore Region: Shoaling and Set-up," *Estuarine and Coastal Marine Science*, Vol. 2, No. 3, July 1974a, pp. 207-234.

Keywords: *Longshore currents, Theoretical model, Nonlinear waves, Setup*

Many previous theories of nearshore effects of ocean waves have used linearized, small-amplitude wave theory which, though giving results in general agreement with observation, is not strictly applicable in this region. The present theory uses a combination of third-order hyperbolic waves (an approximation to cnoidal waves) near the shore and Stokes waves farther out. This is shown to be a suitable assumption for the case of spilling breakers on gentle slopes. The momentum and energy fluxes given by this model are calculated and the consequences for wave shoaling and setup are discussed. (Author)

174. JAMES, I.D., "A Non-linear Theory of Longshore Currents," *Estuarine and Coastal Marine Science*, Vol. 2, No. 3, July 1974b, pp. 235-249.

Keywords: *Longshore currents, Theoretical model, Nonlinear waves*

Recent theories of longshore currents (Bowen, 1969; Longuet-Higgins, 1970) have used linear (Airy) wave theory to determine momentum fluxes in the nearshore region. This paper uses the model for waves in this region described by James (1974). It is found that, unlike the previous theories, the magnitude of the longshore current depends on the parameter $P = T\sqrt{(g/d_b)}$, where T is the wave period and d_b the mean depth at the breaker line. However, for a wide range of typical values of P the two theories give longshore currents of the same order of magnitude. (Author)

175. JOHNS, B., "A Numerical Model of the Approach of Bores to a Shoreline," *Euromech 101* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Surf zone, Bore propagation, Numerical simulation*

Two series of numerical experiments have been carried out. The first of these relates to the approach of a single bore to a shoreline. Results have been obtained which describe the bottom stress, the Reynolds-averaged velocity profile and the distribution of turbulent energy density. The second set relates to the approach of periodic bores to a shoreline. (DHL)

176. JOHNSON, D.W., *Shore Processes and Shoreline Development*, John Wiley & Sons, New York, 1919.

Keywords: *Historical, State-of-the-art, Sediment transport*

This is one of the earliest works on coastal hydrodynamics and processes. Qualitatively discussed are wave setup, longshore currents, and rip currents (undertow) as hydraulic currents due to waves. Book primarily discusses sediment transport and morphology.

177. JONES, D.F., "The Effect of Vertical Seawalls on Longshore Currents," Ph.D. Dissertation, University of Florida, Gainsville, Fla., 1975.

Keywords: *Radiation stress theory, Standing waves, Surf zone structures*

The effects of a vertical seawall in the surf zone on the horizontal distribution of longshore currents and beach profile are investigated. The radiation stress concept is utilized in the analysis. The following basic assumptions are employed: (a) The system is in steady state. (b) The dependent variables are uniform parallel to the beach contours. (c) The magnitude of the standing wave envelope is proportional to the water depth. (d) Linear wave theory may be utilized to describe adequately the wave motion.

Assuming that the time-average bottom shear stress is uniform and balanced by the applied wave stress, a natural equilibrium profile within the surf zone is developed for the case of no seawall. The presence of a seawall in the surf zone is then considered, and a second equilibrium profile is developed, characterized by a series of bar and trough features.

The profile developed with a seawall exhibits a net loss of material from the beach face. The amount of material eroded is shown to be dependent on the position of the seawall. Scour always occurs and is a maximum immediately adjacent to the seawall.

Utilizing the same assumption regarding the nature of the bottom shear

stress, the horizontal distribution of longshore currents is investigated. The maximums and minimums of this velocity profile are found to correspond to the antinodes and nodes, respectively, of a standing wave system produced by the presence of the seawall. (Author)

178. JONSSON, I.G., "Simplified Calculation of the Set-Down for Obliquely Incident Water Waves," Progress Report No. 31, Institute of Hydrodynamics and Hydraulic Engineering, Technical University of Denmark, Lyngby, Denmark, Dec. 1973.

Keywords: *Wave thrust, Wave theory, Derivation methods*

A new approach is reviewed for deriving the wave set-down equation outside to the surf zone. Monochromatic Stokes waves are assumed propagating obliquely into a region with straight and parallel bottom contours. Reflection and dissipation are neglected. The approach simply consists of introducing the integrated momentum equations *parallel* to the coast directly into the basic form of the momentum equation *perpendicular* to the shoreline. Energy conservation between adjacent orthogonals is verified as constant.

179. JONSSON, I.G., and SVEND, N.P., "Calculation of Wave Set-Up," *Euromech* [illegible] Breaking Waves, Surf and Run-up on Beaches, University of Bristol, [illegible], 1973.

Keywords: *Wave thrust, Wave setup, Wave theory*

This study presents an expression for the maximum wave setup, which is based on an integration of the momentum equation across the surf zone in combination with a solitary wave expression for the breaker depth. Comparison with measurements by Saville (1962) and Bowen, et al. (1968) shows qualitative agreement. Only normal incidence of regular waves on a plane beach is investigated.

180. JONSSON, I.G., and JACOBSEN, T.S., "Set-Down and Set-Up in a Refraction Zone," Progress Report No. 29, Institute of Hydrodynamic and Hydraulic Engineering, Technical University of Denmark, Lyngby, Denmark, Aug. 1973.

Keywords: *Wave thrust, Depth refraction effects, Theoretical models*

Assuming linear wave theory, shallow-water approximations and a fixed ratio between wave height and water depth in the surf zone, the methods of Bowen, et al. (1968) are followed to calculate the wave setdown and the setup gradient including the effect of depth refraction on the variations of the mean water level. Letting θ_o be the deepwater angle of incidence, the maximum wave setup varies approximately as $(\cos \theta_o)^{2/5}$, all things being equal. Equations are also presented to calculate the maximum wave setup and thus the variation of the mean water level in the surf zone. They are shown to underestimate the maximum setup at $\theta_o = 0$ compared with the experiments of Bowen, et al. (1968).

181. JONSSON, I.G., SKOVGAARD, O., and JACOBSEN, T.S., "Computation of Longshore Currents," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974, pp. 699-714.

Keywords: *Theoretical model, Boundary shear, Turbulent mixing*

The steady-state profile of the longshore current induced by regular, obliquely incident, breaking waves, over a bottom with arbitrary parallel bottom contours, is predicted. A momentum approach is adopted (i.e., radiation stress). The wave parameters must be given at a depth outside the surf zone, where the current velocity is very small. The variation of the bottom roughness along the given bottom profile must be prescribed in advance. Depth refraction is included also in the calculation of wave setdown and setup. Current refraction and rip currents are excluded. The model includes two new expressions, one for the calculation of the turbulent lateral mixing, and one for the turbulent bottom friction. The term for the bottom friction is nonlinear. Rapid convergent numerical algorithms are described for the solution of the governing equations. The predicted current profiles are compared with laboratory experiments and field measurements. For a plane sloping bottom, the influence of different eddy viscosities and constant values of bottom roughness is examined. (Authors)

183. KAMPHUIS, J.W., "Another Look at Longshore Currents," *the 15th Conference on Great Lakes Research*, Queen's University, Kingston, Ontario, 1972.

Keywords: *Longshore currents, Wave theory*

Many attempts have been made to formulate expressions for the velocity of longshore currents. Some of the more common expressions are discussed and compared with laboratory and field data. The fit of these

formulas to the field data is not very good and a new simplified formula is proposed to take their place. The fit of this relationship is as good as the more complicated expressions and until more accurate field measurements are available, this simple formulation should suffice. (Author)

184. KAMPHUIS, J.W., "Wave-Induced Circulation in Shallow Basins," *Journal of the Waterways, Port, Coastal and Ocean Division*, Vol. 103, No. WW4, Nov. 1977, pp. 570-571.

Keywords: *Longshore currents, Laboratory studies, Wave basins*

The recirculation procedure employed in the wave basin at Queen's University is clarified as employed to model longshore currents.

185. KAWAHARA, M., "A Finite Element Method for Nearshore Current," *Proceedings, Third International Conference on Finite Elements in Flow Problems*, Alberta, Canada, June 1980.

Keywords: *none*

186. KEELEY, J.R., and BOWEN, A.J., "Longshore Variations in Longshore Currents," *Canadian Journal of Earth Science*, Ottawa, Canada, Vol. 14, No. 8, Aug. 1977, pp. 1897-1905.

Keywords: *Longshore currents, Field measurements, Nearshore circulations*

Mean longshore currents in the surf zone were measured along more than 1 kilometer of beach. These measurements were compared with a theoretical model of the system in which the current depends on the angle of incidence of the incoming waves and the longshore variation in both wave height and breaker angle. A wave refraction program was used to compute the values of wave height and breaker angle every 100 meters along the beach from the measured values of wave period and deepwater wave direction. In general, the large-scale variation of currents along the beach was well described by the theory. However, superimposed upon these large scales of motion were fairly regular, small-scale circulation cells which are probably associated with edge waves at the incoming wave frequency. (Authors)

187. KEMP, P.H., "Wave Asymmetry in the Nearshore Zone and Breaker Area," *Nearshore Sediment Dynamics and Sedimentation*, J. Hails and A. Carr, eds., John Wiley and Sons, Inc., New York, 1975, pp. 47-68.

Keywords: *Wave breaking, Wave profiles, Surf zone*

The shape and asymmetry of nonlinear, shoaling water waves are discussed and examples given for asymmetry classification. Profile asymmetry is related to velocity asymmetry and hence to net movement of sediment on the bed. After wave breaking, bore propagation and backwash play dominant roles and the phase difference resulting is related to wave characteristics and beach slope. Laboratory-scale tests are used to study the variables associated with backwash. Reduced backwash results in more shoreward movement of bed material. Flat beaches have little backwash and this is suggested as a reason why beaches flatten to achieve stability. Increased permeability has the same effect.

188. KEMP, P.H., and PLINSTON, D.T., "Internal Velocities in the Uprush and Backwash Zone," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974, pp. 575-585.

Keywords: *Surf zone, Field measurements, Velocity fields, Backwash*

In an earlier paper the authors reported the results of both field and hydraulic model investigations into the reaction of beaches to the action of waves of low phase difference. These waves are those whose time of uprush on the beach is equal to or less than 0.7 T, where T is the wave period. The present paper summarizes the study of the internal velocity field under similar conditions. By making certain simplifying assumptions based on observations of the profile of the wave during uprush and backwash, the surging wave is open to quantitative description. For very low phase differences the uprush is approximately the reverse of the backwash, but to a different time scale. However, as the phase difference approaches the limit for the surging conditions, the uprush starts and may remain in the form of a bore. (Authors)

189. KING, C.A.M., *Beaches and Coasts*, St. Martin's Press, New York, 2d ed., 1972.

Keywords: *Textbook*

The brief section on longshore currents induced by waves only reviews

literature up through 1968; hence all the applications of radiation stress theory are not included.

190. KOMAR, P.D., "The Longshore Transport of Sand on Beaches," Ph.D. Dissertation, University of California, Scripps Institute of Oceanography, San Diego, Calif., 1969.

Keywords: *Longshore currents, Field experiments, Sediment transport*

Simultaneous field measurements of wave and current parameters in the surf zone are made on three beaches under a variety of conditions. Wave energy direction and flux is determined from a linear array of wave pressure sensors near the breakers. Of primary interest is sediment transport rate which is also measured with sand tracers. Two sediment transport models are used to implicitedly derive an empirical equation for the mean, longshore current. This expression is independent of bed slope which is contrary to the theory of mean longshore current as derived from radiation stress theory.

191. KOMAR, P. D., "Nearshore Cell Circulation and the Formation of Giant Cusps," *Bulletin of the Geological Society of America*, Vol. 82, No. 9, Sept. 1971, pp. 2643-2650.

Keywords: *Laboratory study, Longshore currents, Nearshore circulation, Cusps*

Large cusps are common along many shorelines, sometimes isolated but at times forming a rhythmic series of such forms with a uniform spacing. The role of the cell circulation, rip currents and associated longshore currents, in producing such cusps is examined. A series of laboratory wave basin experiments is presented in which the cell circulation of water modifies an initially smooth and straight sand beach. In all cases, it is found that cusps develop in the lee of the rip currents so that a series of cusps is formed with the same spacing as the rip currents. These are compared with giant cusps and beach cusps observed on natural beaches. An equilibrium cusp development is found in the experiments in which, having produced the cusps, all cell circulation and other longshore currents suddenly cease to exist; the rip currents disappear. It is demonstrated that the equilibrium state consists of a balance between the forces that tend to drive a longshore current from an oblique wave approach to the flanks of the cusps, and the forces that normally produced the cell circulation. Cusps, having been produced by rip currents, can therefore be observed on beaches although the rips are no longer present. (Author)

192. KOMAR, P.D., "Longshore Currents and Sand Transport on Beaches," *Proceedings of Civil Engineering in the Oceans/III*, American Society of Civil Engineers, Vol. 1, 1975a, pp. 333-354.

Keywords: *Longshore currents, State-of-the-art, Sediment transport*

A review of the literature and author's previous work is presented. The equation for midsurf longshore current due to oblique wave approach as determined by Komar and Inman (1970) is used to "calibrate" the solution by Longuet-Higgins (1970) for velocity profile across the surf zone.

193. KOMAR, P.D., "Nearshore Currents: Generation by Oliquely Incident Waves and Longshore Variations in Breaker Height," *Nearshore Sediment Dynamics and Sedimentation*, J. Hails and A. Carr, eds., Wiley and Sons, Inc., New York, 1975b, pp. 17-45.

Keywords: *Longshore currents, Oblique waves, Nearshore currents, Nearshore circulation*

Within the nearshore zone wave-induced longshore currents may be generated either by an oblique wave approach to the shoreline, by longshore variations in the wave breaker height, or by combinations thereof. This paper presents equations that combine the *two* generating *mechanisms* and investigate conditions where the two mechanisms might oppose one another. The velocity $\bar{u}$, at the *midsurf* position is found to be given by

$$\bar{u}_l = 2.7\, j_m \sin\alpha_b \cos\alpha_b - \frac{\pi\sqrt{2}}{C_f \gamma_b^{3}} \left(1 + \frac{3\gamma_b^{2}}{8} - \frac{\gamma_b^{2}}{4}\cos^2\alpha_b\right) u_m \frac{\partial H_b}{\partial y}$$

where: α_b is the breaker angle, $\partial H_b/\partial y$ is the longshore variation in wave height, and u_m is the orbital velocity evaluated at the breaker zone. The drag coefficient C_f is 0.008 to 0.018 under normal field conditions and γ_b is the ratio of the wave breaker height to water depth with a value between 0.8 to 1.2. A comparison between theory and all existing field and laboratory data confirms the term due to the oblique wave approach; there are presently no data to test the contribution of the $\frac{\partial H_b}{\partial y}$ term. (Author)

194. KOMAR, P.D., "Evaluation of Wave-Generated Longshore Current Velocities and Sand Transport Rates on Beaches," *Beach and Nearshore Sedimentation*, R.A. Davis, Jr. and R.L. Ethington, eds., Special Publication No. 29, The Society of Economic Paleontologists and Mineralogists, Tulsa, Okla., 1976a, pp. 48-53.

Keywords: *Longshore currents, Wave theory, Sediment transport*

Currents associated with the nearshore cell circulation, including rip currents, redistribute beach sands into a variety of rhythmic topographies, but do not produce longshore sand transport continuously along the shoreline. Waves breaking at an angle to the beach generate longshore currents flowing parallel to the shoreline. These currents in turn interact with the wave surf to produce a longshore transport of sand. A simple equation has been found with which this longshore current velocity can be evaluated for the midsurf position where data are available. Theoretical relationships have been formulated for the complete longshore current distribution across the beach width, but data are lacking. However, the distribution can be made to agree with the available data at midsurf by the proper selection of the drag coefficient. Equations have also been obtained for the evaluation of the sand transport rate, caused either by waves breaking at an angle to the shoreline or by longshore currents generated in other ways. This gives the total sand transport rate. Theoretical relationships have been determined for the distribution of longshore sand transport across the beach width, but again data are lacking to test the equations. The distribution can be calibrated such that, when summed across the beach, it gives the correct total sand transport rate. (Author)

195. KOMAR, P.D., "Nearshore Currents," *Beach Processes and Sedimentation*, 1st ed., Prentice Hall, Inc., Englewood Cliffs, N.J., 1976b, pp. 168-202.

Keywords: *Longshore currents, Nearshore circulation, Radiation stress theory, Laboratory and field investigations, Theoretical models*

A state-of-the-art and knowledge summary of longshore currents and nearshore circulation patterns including rip currents, edge wave generation theories, and surf zone models are discussed in considerable detail in Chapter 7. The fundamental, theoretical background on coastal wave thrust or radiation stress concepts is also reviewed in Chapter 3.

196. KOMAR, P.D., "Beach-Slope Dependence of Longshore Currents," *Journal of the Waterway, Port, Coastal and Ocean Division*, Vol. 105, No. WW4, Nov. 1979, pp. 460-464.

Keywords: *Longshore currents, Wave theory, Beach slope*

An examination is made of the beach slope dependence of longshore currents generated by waves breaking obliquely to the shoreline. The classical data sets from laboratory and field observations of Galvin (1967) along with that from Komar and Inman (1970) are employed to demonstrate that inclusion of the direct dependence of the longshore current velocity on the beach slope as proposed in the Coastal Engineering Research Center (1973) formula leads to considerable error. The relationship

$$\bar{v}_\ell = 1.17\,(gH_b)^{1/2}\sin\alpha_b\cos\alpha_b$$

is proposed instead which has no beach-slope dependence. This equation stems from the work of Komar and Inman (1970) based on the simultaneous solution of two longshore sand transport relations and has some relation to the longshore current formula as given by radiation stress theory.

197. KRAUS, N.C., and SASAKI, T.O., "Influence of Wave Angle on the Longshore Current," *Marine Science Communications*, Vol. 5, No. 2, Feb. 1979, pp. 91-126.

Keywords: *Longshore currents, Theoretical model, Wave angle*

The steady longshore current on a plane beach is modeled to obtain an analytical solution which includes wave refraction, lateral mixing, and an angle-dependent bottom friction stress linear in the current velocity. The simple form of the solution, which is essentially an extension of that of Longuet-Higgins (1970), isolates the effects due to a moderately large incident wave angle and the lateral mixing parameter, P. The angle dependencies of several important quantities such as the location of the maximum longshore current velocity, and the maximum, midsurf, and breaker line current velocities are calculated. Predictions of the model are verified with new detailed laboratory and field measurements. From comparison with observations it appears that mixing parameters less than about 0.1 describe most steady longshore currents which fall under the linear bottom friction force approximation. Values of both the bottom friction and lateral mixing coefficients are determined by fitting the theory to the data. (Authors)

198. KRUMBEIN, W.C., "Shore Currents and Sand Movement on a Model Beach," TM-7 U.S. Army, Corps of Engineers, Beach Erosion Board, Washington, D.C., Sept. 1944.

Keywords: *Longshore currents, Model study, Sand transport*

This is one of the earliest reported model studies in which longshore currents are measured. Current along breaker line is measured by timing the movement of "loosely-woven white string." Velocity variation within surf zone is reported. Study is primarily concerned with sediment transport measurements. End-wall effects on basin circulations were ignored or neglected. Data and conclusions presented are of limited range and value.

199. LEBLOND, P. H., and TANG, C.L., "On Energy Coupling Between Waves and Rip Currents," *Journal of Geophysical Research*, Vol. 79, No. 6, Feb. 1974, pp. 811-816.

Keywords: *Rip currents, Nearshore circulation, Theoretical models, energy*

The theory of rip currents has been extended to include energy exchange between the waves and the rip currents that they produce. This added coupling does not modify the flow field appreciably but changes the wave energy distribution across the surf zone. It is also found that for the same flow field the longshore varying energy density at the breaker line (which causes the currents) is now increased: the energy interaction resists the flow, and larger wave perturbations are needed to induce rip currents. A criterion for rip spacing is advanced based on a minimization of the relative rate of energy dissipation. The results obtained with this criterion do not compare well with observations and indicate that lateral friction, neglected in this model, should play a significant role in the dynamics of rip currents. (Authors)

200. LEE, K.K., "Longshore Currents and Sediment Transport in West Shore of Lake Michigan," *Water Resources Research*, Vol. II, No. 6, Dec. 1975, pp. 1029-1032.

Keywords: *Longshore currents, Field measurements, Lake Michigan*

Longshore sediment transport presents an important problem at the shores along the Great Lakes. Direct field measurements were made on the parameters related to waves, beaches, longshore currents, and sediment transport. By using the field data from Kewaunee County, Lake Michigan, the longshore currents are found to be linearly related to the longshore momentum flux of incident waves at the breaker line, and also the longshore sediment immersed weight transport rate is found in terms of the longshore wave energy flux per unit length of beach. (Author)

201. LEONT'YEU, I.O., "Compensation of Wave-Surge in the Nearshore Zone of The Sea," *Oceanology*, Academy of Sciences U.S.S.R., Vol. 14, No. 4, 1974, pp. 504-508.

Keywords: *Longshore currents, Theoretical three-dimensional models*

Arguments are presented for the concept of a compensating countercurrent as the most general case of wave-surge compensation under natural conditions. The results of theoretical and experimental studies of wave transport of liquid are examined, and an attempt is made to compare them with field observations. Two two-dimensional models of water transport by the waves are proposed, for steep and shallow profiles of the nearshore slope. It is shown that with increasing distance from the shore, the countercurrent gradually moves up from the lower layers in the breaker zone into the upper layers seaward of the zone in which the waves break and then shifts to the middle layer of the water as its depth increases. (Author)

202. LEONT'YEU, I.O., "Physical Model of Water Circulation in the Surf Zone," *Oceanology*, Academy of Science U.S.S.R., Vol. 15, No. 3, June 1976, pp. 304-307.

Keywords: *Surf zone currents, Field measurements, Russia*

Results are discussed of field measurements performed to investigate the distribution of transport velocity in the water column of the surf zone. The main tendencies observed are prevalence of shoreward transport in the upper layers and concentration of seaward flow in the lower layers. An attempt is made to construct a model explaining the effects observed. (DHL)

203. LESNIK, J.R., "Wave Setup on a Sloping Beach," CETA 77-5, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Sept. 1977.

Keywords: *Wave setup, Wave theory, Graphical solution*

This report combines the material previously presented in Sections 2.62 and 3.85 of the Shore Protection Manual. Computation of wave setup on beaches as steep as 1 to 10 (m = 0.01) can be easily determined by graphical means when incident wave conditions are defined. Practical applications are discussed and two example problems are provided. (DHL)

204. LIN, M-C., and HORIKAWA, K., "A Model of Longshore Dispersion in the Surf Zone with Alongshore Current System," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 21, Dec. 1978, pp. 143-155.

Keywords: *Surf zone, Wave theory, Lateral mixing*

A model of longshore dispersion in the surf zone is presented in this paper. This model is based on the assumptions that the surf zone can be considered as an open channel with a triangular cross section and that the lateral variation of longshore current is the primary cause of alongshore dispersion in the surf zone. The rip current effects are ignored in the present treatment. The model is compared with field and laboratory investigation data. Reasonably good agreement is found. (Authors)

205. LIU, P.L.-F., and DALRYMPLE, R., "Bottom Frictional Stresses and Longshore Currents Due to Waves with Large Angles of Incidence," *Sears Foundation: Journal of Marine Research*, Vol. 36, No. 2, May 1978, pp. 357-375.

Keywords: *Longshore currents, Wave theory, Bottom friction, Wave angle*

The analytical forms of the time-averaged bottom shear stress are developed in this paper. The effects of the angle between the direction of wave propagation and the mean currents, and a large angle of wave incidence are included in the study. Two different friction models were obtained based on the relative magnitudes of wave orbital velocity and that of mean currents. These two friction models are applied to longshore currents generated by obliquely incident waves. The lateral mixing is ignored and the beach contours are assumed to be straight and parallel. The strong current model, used when the mean currents are greater than the wave's orbital velocity, is compared with laboratory data. Very good agreement is found. The regions of validity of these two theories are discussed in terms of the angle of incident waves, the slope of the beach, and the bottom friction coefficient. (Authors)

206. LIU, P.L-F., and LENNON, G. P., "Finite Element Modeling of Nearshore Circulation," *Preprints, International Conference on Applied Numerical Modeling*, University of Southampton, July 1977, pp. 103-113.

Keywords: *Nearshore circulation, Numerical simulation, Finite-element method*

In past decades the main effort has been devoted to develop a rational theoretical basis for studying wave-induced nearshore currents. A significant advance was made when the concept of radiation stresses was introduced to the formulation. Based on time- and depth-averaged equations of motion with some empirical hypotheses on the form of breaking waves in the surf zone, several nearshore circulation problems were studied, including longshore currents on a long and straight beach and the rip currents due either to an edge wave component or to the periodic variation in a beach topography. (DHL)

207. LIU, P.L-F., and LENNON, G.P., "Finite Element Modeling of Nearshore Currents," *Journal of the Waterway, Port, Coastal, and Ocean Division*, Vol. 103, No. WW2, May 1978, pp. 175-189.

Keywords: *Bed roughness, Coastal engineering, Finite-element method, Littoral current, Rip currents, Shoreline cover, Topography, Waves*

A finite-element model is developed to compute the nearshore currents induced by breaking waves in the surf zone. The normal incident wave system is employed so as to study the effects of beach topography on the current circulation patterns. The beach topography considered here is of linear plane beach shape with minor undulations in the longshore direction. Ignoring the lateral turbulent diffusion, the finite-element representation of the governing equations of mean currents is obtained by the method of weighted residuals. It is shown that, due to the flexible grid discretization, this model can be used to study problems containing more complex beach topography within a large area of interest. Two types of alongshore beach undulations are investigated: rhythmic topography and localized irregular topography. The locations of rip currents depend on the surf zone width and the onshore-offshore variation of beach profile. (Authors)

208. LIU, P.L-F., and MEI, C.C., "Effects of Breakwater on Nearshore Currents Due to Breaking Waves," TM-57, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Nov. 1975.

Keywords: *Nearshore circulation, Theoretical models, Computer models, Breakwaters, Jetties*

A semiempirical theory of nearshore currents due to breaking waves in close proximity to a shore-connected breakwater or an offshore breakwater, is presented. The effects of diffraction are studied in addition to refraction by shoaling waters. (Authors)

209. LIU, P.L-F., and MEI, C.C., "Water Motion on a Beach in the Presence of a Breakwater 1. Waves," *Journal of Geophysical Research*, Vol. 81, No. 18, June 1976a, pp. 3079-3084.

Keywords: *Nearshore currents, Computer program, Finite differences, Coastal structures*

For a long breakwater on a slowly varying bottom, an asymptotic theory is given which accounts for the combined effects of refraction and Fresnel diffraction of water waves. Numerical examples are given for two cases: an offshore breakwater and an isolated jetty. (Authors)

210. LIU, P.L-F., and MEI, C.C., "Water Motion on a Beach in the Presence of a Breakwater 2. Mean Currents," *Journal of Geophysical Research*, Vol. 81, No. 18, June 1976b, pp. 3085-3094.

Keywords: *Nearshore currents, Computer programs, Finite differences, Coastal structures*

A semiempirical theory of breaking-induced mean currents on a beach is developed here to study the combined effects of refraction and diffraction. With the omission of convective inertia and lateral turbulent diffusion the resulting averaged equations are solved by finite differences. The case of an offshore breakwater is studied in detail, and the predicted current pattern is consistent with laboratory observations and the known tendency of tombolo formation near sandy beaches. Numerical results for an isolated breakwater extending from the shore are also presented, and observational evidences cited. (Authors)

211. LONGUET-HIGGINS, M.S., "Longshore Currents Generated by Obliquely Incident Sea Waves, 1," *Journal of Geophysical Research*, Vol. 75, No. 33, Nov. 1970a, pp. 6778-6789.

Keywords: *Longshore currents, Theoretical model, Wave thrust*

By using known results on the radiation stress associated with gravity waves, the total lateral thrust exerted by incoming waves on the beach and in the nearshore zone is rigorously shown to equal $(E_0/4)\sin 2\theta_0$ per unit distance parallel to the coastline, where E_0 denotes the energy density of the waves in deep water and θ_0 denotes the waves' angle of incidence. The local stress exerted on the surf zone in steady conditions is shown to be given by $(D/c)\sin\theta$ per unit area, where D is the local rate of energy dissipation and c is the phase velocity. These relations are independent of the manner of the energy dissipation, but because breaker height is related to local depth in shallow water, it is argued that ordinarily most of the dissipation is due to wave breaking, not to bottom friction. Under these conditions, the local mean longshore stress in the surf zone will be given by $(5/4\rho U_{max}{}^2 s \sin\theta)$, where ρ is the density, U_{max} is the maximum orbital velocity in the waves, s is the local beach slope, and θ is the angle of incidence. It is further shown that, if the friction coefficient C on the bottom is assumed constant and if horizontal mixing is neglected, the mean longshore component of velocity is given by $(5\pi/8)(s/C)U_{max}\sin\theta$. This value is proportional to the longshore component of the orbital velocity. When the horizontal mixing is taken into account, the longshore currents observed in field observations and laboratory experiments are consistent with a friction coefficient of about 0.010. (Author)

212. LONGUET-HIGGINS, M.S., "Longshore Currents Generated by Obliquely Incident Sea Waves, 2," *Journal of Geophysical Research*, Vol. 75, No. 33, Nov. 1970b, pp. 6790-6801.

Keywords: *Longshore currents, Theoretical model, Wave thrust*

The profile of the longshore current as a function of distance from the swash line is calculated by using the concept of radiation stress (introduced in an earlier paper) together with a horizontal eddy viscosity μ_ϵ of the form $\mu_\epsilon = \rho N x (gh)^{1/3}$, where ρ is the density, x is the distance offshore, g is gravity, h is the local mean depth, and N is a numerical constant. This assumption gives rise to a family of current profiles whose form depends only on the dimensionless parameter $P = (\mu/2)(sN/ac)$, where s denotes the bottom slope, a is a constant charac-

teristic of breaking waves ($\alpha \doteq 0.41$), and C is the drag coefficient on the bottom. The current profiles are of simple analytic form, having a maximum in the surf zone and tending to zero at the swash line. Comparison with the laboratory experiments of Galvin and Eagleson (1965) shows remarkably good agreement if the drag coefficient C is taken as 0.010. The theoretical profiles are insensitive to the exact value of P, but the experimental results suggest that P never exceeds a critical value of 2/5. (Author)

213. LONGUET-HIGGINS, M.S., "Recent Progress in the Study of Longshore Currents," *Waves on Beaches and Resulting Sediment Transport*, R.E. Meyer, ed., 1st ed., Academic Press, Inc., New York, 1972a, pp. 203-248.

Keywords: *Longshore currents, Theoretical models, Wave thrust*

Author reviews state-of-the-art for theories of longshore currents based on radiation stress concepts. Included are reformulations of the fundamental equations to include wave refraction. This is used to interpret observed total sediment transport in terms of a coefficient of bed friction, which author believes to be constant. An excellent discussion of the influence of the lateral, turbulent mixing coefficient on the velocity distribution across the surf zone is presented. It also includes review of the general theory of longshore currents where variations in wave heights along the coastline can give rise to sequences of circulation cells, rip currents, etc., following Bowen (1969). In conclusion author gives suggestions for further research.

214. LONGUET-HIGGINS, M. S., "The Mechanics of the Surf Zone," *Proceedings of the 13th International Congress of Theoretical and Applied Mechanics*, E. Becker and G.K. Mikhailov, eds., Moscow University, Aug. 1972b, pp. 213-228.

Keywords: *Longshore current theory, Wave setup, Rip currents, State-of-the-art*

The author discusses the following topics: radiation stresses; waves in water of slowly varying depth; wave setup; longshore currents; the driving forces; the velocity profile; rip currents; general theory; applications, and sand movement. (DHL)

215. LONGUET-HIGGINS, M.S., "Recent Developments in the Study of Breaking Waves," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 441-460.

Keywords: *Wave breaking, Wave theory, State-of-the-art*

The aim of this paper is to bring together some recent contributions by the author to the calculation both of steep symmetric waves and of time-dependent surface waves. Solitary waves are initially discussed since they closely resemble spilling breakers on gentle slopes. Finally, a new numerical technique is described (MEL, or mixed Eulerian-Lagrangian) with which it has been found possible to follow the development of periodic waves past the point when overturning takes place.

216. LONGUET-HIGGINS, M.S., and COKELET, E.D., "The Deformation of Steep Surface Waves on Water I. A Numerical Method of Computation," *Proceedings of the Royal Society of London*, London, England, Vol. 350, No. 1660, Series A, 1976, pp. 1-26.

Keywords: *Wave theory, Numerical simulation, Nonlinear waves*

Plunging breakers are beyond the reach of all known analytical approximations. Previous numerical computations have succeeded only in integrating the equations of motion up to the instant when the surface becomes vertical. In this paper a new method is presented for following the time history of space-periodic irrotational surface waves. The only independent variables are the coordinates and velocity potential of marked particles at the free surface. At each time step, an integral equation is solved for the new normal component of velocity. The method is faster and more accurate than previous methods based on a two-dimensional grid. (DHL)

217. LONGUET-HIGGINS, M.S., and STEWART, R.W., "Radiation Stress and Mass Transport in Gravity Waves, with Application to 'Surf Beats'," *Journal of Fluid Mechanics*, London, England, Vol. 13, No. 4, Aug. 1962, pp. 481-504.

Keywords: *Wave setup, Wave setdown, Theoretical models, Wave theory, Radiation stresses, Surf beat*

This paper studies the second-order currents and changes in mean surface level which are caused by gravity waves of nonuniform amplitude. The effects are interpreted in terms of the radiation stresses in the waves.

The first example is of wave groups propagated in water of uniform mean depth. The problem is solved first by a perturbation analysis. In two special cases the second-order currents are found to be proportional simply to the square of the local wave amplitude: (a) when the lengths of the groups are large compared to the mean depth, and (b) when the groups are all of equal length. Then the surface is found to be depressed under a high group of waves and the mass transport is relatively negative there. In case (a) the result can be simply related to the radiation stresses, which tend to expel fluid from beneath the higher waves. (Authors)

218. LONGUET-HIGGINS, M.S., and STEWART, R.W., "A Note on Wave Set-Up," *Journal of Marine Research*, Vol. 21, No. 1, Jan. 1963, pp. 4-10.

Keywords: *Wave setdown, Wave setup, Theoretical model, Wave thrust, Radiation stresses*

Seaward of the breaker zone, the observations of Saville are in good qualitative agreement with the prediction that the mean surface level is increasingly depressed toward the shoreline, proportionally to F(n), i.e., to $(\sigma^2 h/g)^{-3/2}$ very nearly. The observed depressions are on the average greater than the theoretical by a factor of about 1.7. Between the breaker zone and the stillwater level the surface tends to rise again in the way described by $d\bar{\zeta}/dx = Q(dh/dx)$, with the factor Q equal to 0.15. (Authors)

219. LONGUET-HIGGINS, M.S., and STEWART, R.W., "Radiation Stress in Water Waves; a Physical Discussion with Applications," *Deep-Sea Research*, Oxford, England, Vol. 11, No. 4, August 1964, pp. 529-562.

Keywords: *Wave thrust, Radiation stresses, Wave setup and wave setdown, Wave theory, Physics*

The radiation stresses in water waves play an important role in a variety of oceanographic phenomena, for example in the change in mean sea level due to storm waves (wave " setup"); the generation of "surf beats"; the interaction of waves with steady currents; and the steepening of short gravity waves on the crests of longer waves. In previous papers these effects have been discussed rigorously by detailed perturbation analysis. In the present paper a simplified exposition is given of the radiation stresses and some of their consequences. Physical reasoning, though less rigorous, is used wherever possible. The influence of capillarity on the radiation stresses is fully described for the first time. (Authors)

220. LUNDGREN, H., "The Concept of the Wave Thrust," Progress Report No. 3, Coastal Engineering Laboratory, Technical University of Denmark, Lyngby, Denmark, July 1962.

Keywords: *Radiation stress theory*

This is a very early, pioneering effort to derive an expression for the excess momentum flux in fluid flow due to waves now called radiation stress. See Program Report 20 for some corrections, December 1969.

221. LUNDGREN, H., "Wave Thrust and Wave Energy Level," *Proceedings of IAHR Congress*, London, 1963, pp. 147-157.

Keywords: *Radiation stress theory, Wave setup*

In steady flow, the theorems of momentum and energy are of a fundamental nature. By applying these theorems to progressive waves, the concepts of wave thrust and wave energy level emerge. (Author)

222. LUNDGREN, H., "Physics and Mathematics of Waves in Coastal Zones," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 880-885.

Keywords: *Wave theory*

This paper presents a discussion of four methods available for the computation of small-amplitude periodic waves in coastal zones of arbitrary topography. With no reflections (or reflection from a single structure) the methods that proceed in space (Refraction and Propagation) or time (Timestep) seem the natural ones from a physical point of view. With repeated reflections, recourse must be taken to the solution of an Elliptic boundary value problem. It is suggested that a P-method based on (energy) flux lines and energy fronts be developed for the cases where the R-methods give crossing orthogonals. (Author)

223. McCULLOUGH, J.R., "Near Surface Ocean Current Sensors: Problems and Performance," *Proceedings of a Working Conference on Current Measurement*, Technical Report DEL-SG-3-78, National Oceanic and Atmospheric Administration and University of Delaware, June 1978, pp. 9-34.

Keywords: *Measurements, Instrumentation, Current meters*

When current meters are used to measure mean horizontal currents in the presence of surface gravity wave motions, immunity to the veritical component of flow is important, even though the net vertical flow averages to zero and is normal to the desired horizontal components. A technique is presented for estimating the magnitude of the errors introduced by imperfect rejection of the off-axis flows (cross-talk) from laboratory measurements of the current meter "vertical-cosine-response." The predicted dynamic response is shown to compare favorably with laboratory measurements. The measured steady-state vertical-cosine-response functions for several practical current sensors are summarized and used to estimate the magnitude of wave-induced errors in horizontal mean current measurements. A new dye technique for evaluating near-surface current meter performance in waves is shown. (Author)

224. McKENZIE, R., "Rip Current Systems," *Journal of Geology*, Vol. 66, No. 2, Mar. 1958, pp. 103-113.

Keywords: *Nearshore circulation, Rip currents, Field study*

Under certain conditions of nearshore slope and wave activity, the major seaward drainage of water which has been moved toward the beach in waves and breakers is in the form of rip currents. These currents are particularly well developed along the coast of New South Wales, where they exhibit a systematic form. Each beach has a complete rip current system which is controlled by the particular features of the beach and which is varied by such factors as the size and regularity of the waves, the tide, and the wave source direction. Although strict principles cannot be applied to the variations of these systems it is possible to evaluate the major factors involved and to analyze and predict the forms of each system under variable conditions. (Author)

225. McREYNOLDS, D.J., "Wave Set-Up and Set-Down Due to a Narrow Frequency Wave Spectrum," M.S. Thesis, U.S. Naval Post Graduate School, Monterey, Calif., 1977.

Keywords: *Wave setdown, Wave setup, Wave theory, Irregular wave [illegible]*

A narrow band wave spectrum was applied to theoretical relationships previously developed for *setdown* and *setup* in an attempt to find second-order nonsteady solutions for these concepts. The initial effort was to apply this spectrum to the radiation stress tensor using linear wave theory. Another development was attempted by incorporating the spectrum and the solution of the long wave equation into the Bernoulli and vertical momentum equations. Results obtained indicate that the solution for mean water level outside the surf zone is composed of a steady component and a periodic unsteady component; the periodic component being of the form of a long wave with a frequency lower than the components of the wave spectrum. The solution for *setup* is then composed of the same type of components. The exact relationships depend on the patching process that is made for the solution through the breaker line. (Author)

226. MADSEN, P.A., and SVENDSEN, I.A., "On the Form of the Integrated Conservation Equations for Waves in the Surf Zone," Progress Report Number 48, Institute for Hydrodynamic and Hydraulic Engineering, Technical University of Denmark, Lyngby, Denmark, Apr. 1978.

Key words: *Surf zone, Wave theory, Conservation equations*

A plane incompressible turbulent flow with unsteady mean motion and appreciable free surface fluctuations is considered. The vertically integrated equations of mass, momentum and energy conservation are derived for the volume of fluid bounded by the mean free surface. This is an extension of the results of Hasselmann (1979). (Authors)

227. MADSEN, O.S., OSTENDORF, D.W., and REYNOLDS, A.S., "A Longshore Current Model," *Symposium on Technical, Environmental, Socioeconomic and Regulatory Aspects of Coastal Zone Management*, American Society of Civil Engineers, Vol. 3, 1978, pp. 2332-2341.

Keywords: *Longshore current, Bed shear stress, Modeling*

The analytical model for longshore current profile on a plain beach by Longuet-Higgins (1970,1972) is modified to incorporate a nonlinear bed shear stress. It is calibrated using the laboratory data of Galvin and Eagleson (1965) so that an explicit formula for bottom friction can be derived. Bottom friction is dependent on bottom roughness and relative scale of the longshore current to wave orbital velocity. Other laboratory data are used to verify the model on slopes of 1 on 10 and agreement is said to be excellent. Other slopes less than 1 on 10 require modifications to the model.

228. MANOHAR, M., MOBAREK, I.E., and MORCOS, A., "Longshore Currents and Waves at Burullus Coast," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1974, pp. 685-698.

Keywords: *Longshore currents, Field measurements, Egypt*

Littoral currents within the breaker zone and currents other than those induced by waves beyond the breaker zone exist with considerable magnitude along the Nile Delta coast. Analysis of the littoral currents within the breaker zone by four semiempirical formulas involving energy, momentum and radiation stress principles indicates good correlation between predicted and observed velocities. The Galvin-Eagleson approach gives the best fit. Current data are statistically analyzed enabling the determination of the magnitude, direction and percentage of occurrence of any particular littoral current for any particular period.

More comprehensive studies of the currents climate within the breaker zone and beyond the breaker zone for the entire Nile Delta coast covering a large number of years are underway. (Authors)

229. MARESCA, J.W., and SEIBEL, E., "Terrestrial Photogrammetric Measurements of Breaking Waves and Longshore Currents in the Nearshore Zone," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 681-700.

Keywords: *Measurement techniques, Surf zone*

Study of the feasibility of shore-based, oblique photograhic monitoring of breaking waves, water levels, and currents within the surf zone. This paper describes a new method of oblique single-image and stereoscopic-image analysis, the potential errors, and the types of measurements that can be made in the surf zone. Examples of application are presented to demonstrate the technique. Sophisticated photographic equipment is not required to collect, analyze, and interpret the data. (DHL)

230. MARUYAMA, K., and HORIKAWA, K., "Generation of Rip Currents in a Laboratory Basin," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 20, Dec. 1977, pp. 129-158.

Keywords: *Nearshore circulations, Rip currents, Laboratory experiments, Numerical models*

Rip current phenomena were studied in the laboratory to better understand their generation mechanisms. It was found that normally incident regular waves on a plain beach in a wave basin with wave paddle create free oscillations or "cross waves" at various angles to the beach. The wave height variation alongshore that results is shown due to the superposition of the incident and cross waves. Rip currents were then observed. These oblique, cross waves are not alongshore edge waves but serve the same purpose. Numerical, computer-based simulations agreed with the laboratory observations.

231. MASSEL, S.R., and ZEIDLER, R.B., eds., *Proceedings, International Investigations Lubiatowo - 76 (Hydro- and Litho-dynamical Processes in the Marine Coastal Zone) in Hydro-technical Transactions*, Vol. 41, Warsaw, Poland, 1980.

Keywords: *Coastal processes, Field experiments, Poland*

In 1973 wave dynamical phenomena were measured near the village of Zingst in the German Democratic Republic (GDR) by a joint team of scientists from Bulgaria, GDR, Poland, and the USSR. Then in 1974 at Lubiatowo, Poland, currents, diffusion and exchange of waters and litho-dynamical processes were measured. The report contains mostly articles on sediment transport along the coast but includes six papers about surf zone hydrodynamics at Lubiatowo that discuss field measurement results.

232. MATUSREVSKIY, G.V., "Radiation Stress (Wave Thrust) and Mean Wave Level of Nonregular Three-Dimensional Waves in a Shoaling Zone," *Atmospheric and Oceanic Physics*, Izv. Academy of Sciences, U.S.S.R., Vol. 11, No. 1, 1975, pp. 42-46.

Keywords: *Wave setdown, Wave setup, Wave theory, Irregular waves*

The variation of radiation stress and mean wave level during the propagation of three-dimensional nonregular waves in a shoaling zone is considered. The investigation is based on the momentum-flux balance equation derived earlier by Longuet-Higgins and Stewart, which they applied to monochromatic waves. Relations describing the variation of the radiation stress (wave trust) and mean wave level in the zone in which the latter decreases and relations giving the elevation of this level are derived. An example of calculation of the level trend in a littoral zone is given. (DHL)

233. MEADOWS, G.A., "Time Dependent Fluctuations in Longshore Currents," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 660-680.

Keywords: *Longshore currents, Field study, Unsteady velocity*

During constant sea-state conditions, longshore current velocities were monitored continuously for 15-minute periods separated by 15-minute periods separated by 15-minute intervals. Three ducted impellor flowmeters were placed at equally spaced vertical positions through the water column. Sequential measurements were made with similar vertical current meter arrays at different locations across the surf zone. Simultaneous measurements of wave height, period and celerity were made at stations placed at equal intervals from the outer surf zone to the beach. The 15-minute continuous records were subjected to spectral analysis. This analysis showed that the major power associated with flucutations in the longshore current velocity field occurs in two major frequency bands. A significant spectral peak was coincident with the breaker period of the incident wave field, 4.2 seconds and, another dominant signature occurred at 78.8 seconds. Attenuation with depth of both the steady and fluctuating components of the longshore current flow field was relatively small. The maximum observed velocities for each station and each vertical current meter position varied from 90 to 150 percent above the observed mean longshore current velocity. However, at each station, variation of the means with depth was not appreciable and thus supports the results from time- and space-averaged theories of vertical uniformity in longshore currents, away from the boundary layer. (Author)

234. MEADOWS, G.A., "A Field Investigation of the Spatial and Temporal Structure of Longshore Currents," Ph.D. Dissertation, Purdue University, West Lafayette, Indiana, 1977.

Keywords: *Longshore currents, Field study, Unsteady flow fields*

Longshore currents are generated by wind waves approaching a coastline at an angle and are strong narrow currents flowing parallel to the beach through the surf zone. Knowledge of the spatial and temporal character of this flow field has been markedly lacking. The horizontal and vertical distribution of the longshore current flow field has not previously been measured on a natural beach.

This field investigation was conducted to obtain simultaneous and continuous measurements of the horizontal, vertical and temporal variability of the longshore current flow field. The present study has resulted in a two-dimensional mapping, across the surf zone and with depth, of the longshore current flow field. The vertical structure of the mean longshore current flow field is nearly uniform with depth, with a narrow bottom boundary layer and sharp velocity gradients at the water-sediment interface. This investigation has also shown that the total longshore current velocity vector, at any point across the surf zone, is composed of three distinct velocity components. These components are: (a) a steady longshore current velocity component, (b) a long-period fluctuation velocity component which tends to be out-of-phase with the incident wave field, and (c) a short-period fluctuating longshore current velocity component which tends to be in-phase with the incident wave field.

The results of this study have further indicated that neither the deterministic radiation stress approach to the prediction of longshore currents, nor a probabilistic formulation, provide adequate prediction of the magnitude or distribution of the longshore current velocity across the surf zone. In addition, the existence of a low velocity zone in the longshore current flow field has been isolated over the submarine bar. It appears that existing analytical formulations for longshore current flow prediction must be reevaluated in light of the findings of this study. (Author)

235. MEI, C.C., and ANGELIDES, D., "Longshore Circulation Around a Conical Island," *Coastal Engineering*, Vol. 1, No. 2, Mar. 1977, pp. 31-42.

Keywords: *Nearshore circulation, Longshore currents*

This paper is concerned with the averaged circulation caused by waves breaking along the beach of a constant slope around a circular island in a sea of constant depth. It is reasoned that the fraction pattern determines the extent of longshore circulation. In particular, for an island so large that there is a lee shore which is not affected by the refracting waves, two current cells are found on two sides of the island with respect to the wave direction, without significant penetration in the lee shore region. This enhances the creation of two sandspits which may grow to form a looped bar, mainland. For an island so small that the extent of the lee shore vanishes, the two current cells collide at the center of the island lee and form a single rip current. This is used to explain the presence of a single tombolo. (Authors)

236. MEI, C.C., and LIU, P.L-F., "Effects of Topography on the Circulation in and near the Surf Zone - Linear Theory," *Estuarine and Coastal Marine Science*, London, England, Vol. 5, No. 1, Jan. 1977, pp. 25-37.

Keywords: *Nearshore circulation, Computer program, Bathymetric variations*

Rhythmic variation in depth along the shoreline causes variations in the radiation stress components and in the mean sea level in the surf zone. In particular, the effect of ray deflection due to refraction affects the component Sxy only, where x is in the offshore and y in the alongshore directions respectively, and tends to oppose the influences of other components. A linearized theory for the mean current is given for normal incidence and small depth perturbation. Lateral turbulence is ignored. The positions of the rip currents are shown to depend on the surf zone width and the onshore-offshore variation of depth.(Authors)

237. MERO, T.N., and APPELL, G.F., "Marine Dynamics and its Effects on Current Measuring Transducers," *National Bureau of Standards Flow Measuring Symposium*, Gaithersburg, Md., Feb. 1977.

Keywords: *Instruments, Current meters, Calibration, Dynamics*

238. MEYER, R.E., and TAYLOR, A.D., "Run-Up on Beaches," *Waves on Beaches and Resulting Sediment Transport*, R.E. Meyer, ed., 1st ed., Academic Press, Inc., New York, 1972, pp. 357-411.

Keywords: *Water wave theories, Beaches and waves, Sediment transport*

This book offers an interdisciplinary view of the state of physical research in coastal oceanography. It presents the proceedings of a symposium in which survey and research papers were presented by oceanographers, mathematicians, geologists, and engineers on such topics as: observational wave records; wave refraction and resonance; wave shoaling, breaking and runup; the mathematics of water waves; longshore currents; and sediment transport, suspension, and accumulation. The paper by Longuet-Higgins can be considered a review of the state of knowledge on longshore currents up through 1971.

239. MEYER, R.E., and TURNER, R.B., "Some Three-Dimensional Effects in Surf," *Journal of Geophysical Research*, Vol. 72, No. 10, May 1967, pp. 2513-2518.

Keywords: *Surf zone, Theoretical equations*

The asymptotic equations of surf are derived for shallow beaches with a geometry causing longshore variations in the water motion. Such surf is generally governed by three-dimensional nonlinear shallow-water equations. When a seabed profile parallel to shore is of gentler slope than the profile normal to shore, however, the asymptotic equations are shown to differ only in minor respects from those of two-dimensional surf.

Such "weakly three-dimensional" surf can be analyzed directly in terms of the results of the two-dimensional theory and the runup bounds of that theory are extended accordingly. (CHL)

240. MILLER, C.D., "Hydrodynamic Instability in the Surf Zone and the Formation of Rip Current Gyres," Ph.D. Dissertation, Florida State University, Tallahasse, Fl., 1977.

Keywords: *Nearshore circulation, Wave theory, Rip currents, Stability analysis*

An analytical study to calculate the eigenvalues of the system of equations and boundary conditions for shore normal approach of waves on a plane beach is conducted. The main hypothesis is that small perturbations will become unstable at some wavelength to extract energy from wave set-up and convert it into circulation cells. The objective is to determine the longshore dimension of the cells as a function of the physical parameters and to reproduce the broad outlines of the circulation. The equations are the usual set of depth-integrated and time-averaged variables and include bottom friction, wave breaking but not lateral turbulent mixing. The characteristic (eigen) wave numbers are found to depend on the wave energy dissipation rate across the surf zone (i.e. beach slope) and the bottom friction coefficient. Steeper beach slopes decrease the eigenvalues. Larger bottom friction factors (rougher beds) increase the eigenvalues. The range of eigenvalues computed was found to match field observations but the data are not sufficient to verify the parameter trends.

241. MILLER, C.D., and BARCILON, A., "The Dynamics of the Littoral Zone," *Reviews of Geophysics and Space Physics*, Vol. 14, No. 1, Feb. 1976, pp. 81-91.

Keywords: *Longshore currents*

Some of the properties of the surface gravity waves were reviewed and their modification observed as they entered the littoral zone. Theoretical and

experimental modeling of processes pertaining to the nearshore are discussed and compared with field observations. In particular the present knowledge is reviewed that pertains to the dynamics of rip currents, longshore currents, and computer modeling of beach deformation due to wave-induced erosion or accretion. (Authors)

242. MILLER, C., and BARCILON, A., "Hydrodynamic Instability in the Surf Zone as a Mechanism for the Formation of Horizontal Gyres," *Journal of Geophysical Research*, Vol. 83, No. C8, Aug. 1978, pp. 4107-4116.

Keywords: *Nearshore circulation, Theoretical models*

The wave-induced horizontal circulation on a mildly sloping beach is modeled analytically. Specific interest is in the cellular flow that is induced when monochromatic waves come in normal to straight, parallel, and nondeformable bottom contours, and when the determining of the longshore dimension of the observed uniformly spaced cells as a function of the physical parameters of the problem is needed. The energy for these motions is derived from the potential energy stored in the wave-induced sea surface setup. It is postulated that infinitesimal perturbations of the proper wavelength will extract the energy associated with this setup and convert it into the circulation velocities of the gyres. (DHL)

243. MILLER, R. L., "Role of Vortices in Surf Zone Prediction: Sedimentation and Wave Forces," *1975 SPEM Research Symposium*, Special Publication No. 24, R.A. Davis, Jr. and R.L. Ethington, eds., Society of Economic Paleontology and Mineralogy, 1976, pp. 92-114.

Keywords: *Surf zone, Wave breaking, Turbulence, Wave theory*

There are difficulties in the creation of numerical prediction models in the surf zone. Specific examination of fundamental breaker mechanics is necessary, if successful prediction is to be achieved. Investigation of the internal velocity field indicates the importance of "breaker vortices" whose size and strength are a function of breaker shape. Numerous experiments have provided data for a detailed analysis of the vortices. As a result, a first approximation model is discussed, although further work is necessary. The effect of breaker vortices is indicated in three applications: (a) forces on the surf zone, (b) impact pressures due to [illegible] the interaction of postbreaking bore and foreshore. In each case the reliability of prediction is considered. (Author)

244. MILLER, R.L., and ZIEGLER, J.M., "Vector Components of Internal Velocity Field in Breaking Waves," *Transactions of the American Geophysical Union*, Vol. 48, No. 1, Mar. 1967, p. 146.

Keywords: *Breaking waves, Velocity fields, Field study, Instrumentation*

A field study of the internal velocity field in breaking waves is carried to its final phase. Simultaneous horizontal and vertical velocity components in the breaker are taken at a series of positions from crest to sea floor and front to back of the breaker. These data are taken on breakers, in nature, using a pair of magnetic fluxmeters in vertical and horizontal position, with simultaneous resistance wire data for surface time history. Breaker heights varied from 3 to 7 feet. Combined data from more than 100 breakers are presented in the form of a vector map in u,w. Results are compared with theory and with experimental data. The possibility of characterizing the breaker as a system of vortices is suggested. (Authors)

245. MINZONI, A.A., "Nonlinear Edge Waves and Shallow Water Theory," *Journal of Fluid Mechanics*, London, England, Vol. 74, Pt. 2, Mar. 1976, pp. 369-374.

Keywords: *Edge waves, Theoretical models, Variable topography*

Nonlinear effects are considered for shallow-water edge waves on beaches with a general depth distribution. The case of uniform depth away from the shoreline is considered in detail. It is shown that the results obtained are in qualitative agreement with those obtained by Whitman (1976) using the full nonlinear theory for a beach of constant slope. (Author)

246. MINZONI, A.A., and WHITMAN, G.B., "On the Excitation of Edge Waves on Beaches," *Journal of Fluid Mechanics*, London, England, Vol. 79, Pt. 2, Feb. 1977, pp. 273-287.

Keywords: *Edge waves, Theoretical model, Beaches*

The excitation of standing edge waves of frequency $1/2\omega$ by a normally incident wave train of frequency ω has been discussed previously (Guza and Davis, 1974; Guza and Inman, 1975; Guza and Bowen, 1976) on the basis of shallow-water theory. Here the problem is formulated in the full water-wave theory without making the shallow-water approximation and

solved for beach angles $\beta = \pi/2N$, where N is an integer. The work confirms the shallow-water results in the limit N>>1, shows the effect of larger beach angles,and allows a more complete discussion of some aspects of the problem. (Authors)

247. MIZUGUCHI, M., "Eigenvalue Problems for Rip Current Spacing," *Proceedings of the Japanese Society of Civil Engineering*, Tokyo, Japan, Vol. 248, Apr. 1976, pp. 83-88.

Keywords: *Nearshore circulation, Wave theory, Stability analyses*

The fundamental, time-averaged, radiation stress theory equations of energy motion, and mass conservation in the nearshore region are used to form a steady-state eigenvalue problem. The rip current spacing is associated with the existence of the eigenvalue system. The eigenvalues can exist only when a linear friction factor inside the surf zone depends on a higher power of the offshore coordinate. (Author)

248. MIZUGUCHI, M., "Averaged Friction Factor for Wave-Induced Nearshore Circulation," *Japanese Conference on Coastal Engineering*, Japan Society of Civil Engineers, 1979.

Keywords: *Nearshore circulation, Radiation stresses, Friction*

Generation of nearshore circulation system is considered on the basis of the fact that the composition of cross wave and normal incident wave is closely connected with the generation of circulation. The velocity potential is derived by considering both normal incident waves and cross waves. The radiation stresses are derived from the velocity potential and water surface elevation with the following three assumptions: (a) the long wave approximation valids, (b) the cross wave is sufficiently refracted by the point of wave breaking, and (c) the amplitude of cross wave is smaller than that of normal incident wave. The velocity field over the nearshore circulation zone is obtained and it makes possible to evaluate the mean friction coefficient utilizing the detailed laboratory velocity measurement over a uniform slope. The laboratory experiment is performed in the wave basin 1.2 meters wide and 6 meters long. Dimensionless average friction factor is calculated by using laboratory data and the obtained value is in the range of 0.01 and 0.03. (Author)

249. MIZUGUCHI, M., "An Heuristic Model of Wave Height Distribution in the Surf Zone," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Surf zone, Energy dissipation, Theory, Wave decay*

A semiempirical model is developed with the aid of laboratory data to estimate wave height distributions and setup in the surf zone for bar-trough and step-type beaches. This allows a broken wave to re-form and propagate where depth is constant in the surf zone. A nonconservative wave energy equation is applied. The rate of energy dissipation is formulated in terms of mean wave parameters (amplitude, period) and turbulent eddy viscosity that varies throughout the surf zone and gives relatively weak internal energy losses where wave reformation is expected. One additional constant is required besides the usual breaker index for uniformly sloping beaches. The author evaluated this constant from his laboratory data and also found best agreement between the theory and data when surf zone energy was given by 1/6oga.

250. MIZUGUCHI, M., and HORIKAWA, K., "Physical Aspects of Wave Induced Nearshore Current System," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 607-625.

Keywords: *Nearshore circulation, Wave theory, Laboratory experiment*

The wave-induced nearshore current system can be classified into two types: free type and forced type. In a laboratory experiment, a kind of forced current system was observed which is created by a periodic breaking wave height distribution caused by "cross wave." Offshore currents always flow through the lower wave height region both inside and outside of a breaker line. When the surf zone was rather wide, a double circulation pattern was observed where wave current interaction might be important. According to the experimental results, it is proposed to consider that the observed current system in fields should be interpreted as the forced type current system where irregular bottom topography plays a crucial part. (Authors)

251. MIZUMURA, K., "Littoral Currents Around Breakwaters," *Coastal Structures 79*, American Society of Civil Engineers, Vol. 2, 1979, pp. 778-791.

Keywords: *Longshore currents, Breakwaters, Model studies*

Constructing the model of prototype in laboratory wave basin, the distributions of wave height, the littoral currents, and the shoreline changes before and after the construction of breakwaters were compared. This provided information about the characteristics of the distribution of wave height and littoral currents around a breakwater, and the relation between these informations and the resultant shoreline changes was studied. Finally, it can be shown that the local flow pattern such as the rip currents does not influence the shoreline changes. (Author)

252. MOORE, G.W., and SCHOOL, D.W., "Coastal Sedimentation in Northwestern Alaska," TEI-779, U.S. Geological Survey, pp. 43-65, 1961.

Keywords: *Longshore currents, Field measurements*

Daily measurements were made during the summer of 1960 at Ogoturuk Beach, Alaska. Breaker angle was measured to nearest 5° by compass, breaker height observed to nearest tenth of a meter, and current estimated by dye patch timing. A gravel beach was observed with steep slope. Some runs had longshore current in opposite direction from wave angle approach.

253. MUNK, W.H., "Surf Beats," *Transactions of the American Geophysical Union*, Vol. 30, No. 6, Dec. 1949, pp. 849-854.

Keywords: *Irregular waves*

Irregular oscillations of the nearshore water level, with periods of the order of several minutes, are correlated with fluctuations in the height and period of incoming waves. (Author)

254. MURTY, C.S., VEERAYYA, M., and VARADECHARI, V.V.R., "Littoral and Rip Currents Off Calangute Beach, GOA," *Indian Journal of Marine Sciences*, New Delhi, India, Vol. 4, No. 1, June 1975, pp. 1-4.

Keywords: *Longshore currents, Rip currents, Field studies, India*

Littoral currents were measured by injecting rhodamine B dye into the surf zone at distances of about 200 meters along the beach (from Sinquerina to Baga) during January to September 1972. These currents were associated with the mass transport due to breaking waves and are directed toward north during a greater part of the fair-weather season. During premonsoon and monsoon months, the littoral currents were northward in some places and southward in other places. Littoral current velocities which generally depend on the breaker heights, angle of incidence of wave orthogonals to the shore, shoreline configuration, the nearshore bottom topography and the rise and fall of water level due to tides, were found to be higher during monsoon as compared to fair-weather season. Rip currents along certain parts of the beach appear to be due to the convergence and divergence of wave energies. The area where rip currents were persistently observed in most of the surveys was demarcated as dangerous to bathers. The changes in current regimes were reflected in the patterns of sediment distribution and sediment transport. (Authors)

255. NIEDORODA, A.W., "Nearshore Currents Due to Momentum Transfer from Shoaling Waves," *Transactions of the American Geophysical Union*, Vol. 53, No. 4, Apr. 1972, p. 421.

Keywords: *Nearshore circulation, Wave theory, Wave thrust*

This study used the radiation stress concept to explain the formation of horizontally circulating currents due to nonuniform bathymetry along the shore. The nonuniform bathymetry causes a nonuniform wave energy density due to wave refraction. In areas of wave energy concentration, such as over shoals and transverse bars, spilling waves develop. Momentum is transferred from the waves to the nearshore currents. The normal component of radiation stress tensor must be considered to contribute to or to dominate the production of the discrete part of the nearshore circulation cells which flows toward the beach atop the shoal or bar. (Author)

256. NIELSEN, P., "Turbulent Mixing and Shear Stresses in the Surf Zone," Progress Rept. No. 42, Institute of Hydrodynamic and Hydraulic Engineering, Technical University of Denmark, Lyngby, Denmark, Apr. 1977.

Keywords: *Surf zone, Turbulent shear-stress models*

A knowledge of lateral mixing coefficient t_x is necessary for estimating lateral shear stresses in connection with longshore current profiles. Four existing formulas for the average mixing coefficient $\bar{\epsilon}_x$ are examined against experiment data from the laboratory and field. A new physical interpretation is presented for the theory with best experimental fit. It appears $\epsilon_x \alpha |x| \sqrt{gh}$.

257. NODA, E. K., "Rip Currents," *Proceedings of the 13th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1972a, pp. 653-668.

Keywords: *Nearshore circulation, Rip currents, Theoretical model*

The generation and stabilization of rip current circulation patterns is considered herein. An analytic model is developed to simulate the wave hydrodynamic processes in the nearshore zone, strongly influenced by the local bottom topography. The wave-induced nearshore circulation pattern is compared and the results compared to prototype field data. (Author)

258. NODA, E.K., "Wave Induced Circulation and Longshore Current Patterns in the Coastal Zone," Report No. TC-149-3, Tetra Tech, Inc., Pasadena, Calif., Sept. 1972b.

Keywords: *Nearshore circulation, Longshore currents, Analytical model, Spatial wave variations, Rip currents*

The report presents a theoretical analysis on the generation and stabilization of nearshore, wave-induced circulation and longshore current patterns produced by the interaction of the incoming waves and local bottom topography. This interaction results in a spacial variation of wave characteristics which produces the driving mechanism for nearshore circulation patterns. Both normal and oblique wave incidence are considered with the imposed beach profiles developed from an examination of prototype data. The analytical model results are compared to field measurements and yield optimistic results. (Author)

259. NODA, E.K., "Wave-Induced Nearshore Circulation," *Journal Geophysical Research*, Vol. 79, No. 27, Sept. 1974, pp. 4097-4106.

Keywords: *Nearshore circulation, Theoretical models*

A theoretical analysis is presented of nearshore wave-induced circulation patterns produced by the interaction of incoming and local bottom topography. This interaction results in a spatial variation of wave characteristics that produce a possible driving mechanism for nearshore circulation patterns. Both normal and oblique wave incidences are considered with the imposed beach profiles developed from an examination of prototype data. The analytical model results are compared with field measurements and yield optimistic results. (Author)

260. NODA, E.K., et al., "Nearshore Circulations under Sea Breeze Conditions and Wave-Current Interactions in the Surf Zone," Report No. TC-149-4, Tetra Tech, Inc., Pasadena, Calif., Feb. 1974.

Keywords: *Nearshore circulations, Wave-current interactions, Numerical models*

Numerical models for nearshore circulation patterns in the surf zone were developed and applied to an observed condition subjected to a sea breeze environment. Bottom topography and input waves were derived from observed data to predict surf zone circulation as a function of time of day. It was found that many features observed in the surf zone were modeled but wave-current interactions are known to be important. Wave-current interactions were modeled for shallow water assuming a two-dimensional motion which included rip current and longshore current components. The refraction effects caused by even small currents produce major changes in the wave-induced driving forces in the surf zone which lead to the prediction of entirely different rip current patterns when wave-current interactions are considered. Numerical results are presented and a discussion of the numerical technqiues is included. A review of water wave theories to include mass transport, vorticity and current was made for a vertical section in shallow water of constant depth. (Authors)

261. NUMMEDAL, D., and FINLEY, R.J., "Wind-Generated Longshore Currents," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 2, 1978, pp. 1428-1438.

Keywords: *Longshore currents, Wind effects, Field observation, Statistical analysis*

This paper evaluates through the use of a stepwise multiple regression procedure, whether parameters descriptive of the surf zone wave field adequately explain the variability in longshore current velocities, or if the inclusion of additional physical environmental parameters could significantly improve the ability to predict such currents. The data set consists of 250 LEO observations, collected on a seasonal basis over 1 year at Debidue Island beach, South Carolina.

A regression analysis was performed both on linear combinations of all measured wave parameters and on nonlinear parameter combinations proposed in various semiempirical predictive equations. Invariably, in all the regression analyses, the longshore component of the wind velocity

proved to be the independent variable explaining most of the observed variance in the current velocity. Therefore, the statistical data analysis presented in this paper strongly suggests that wind stress can be a most significant factor in surf zone current generation. (Authors)

262. OLSEN, A.J., "The Kinematics of Breaking Waves in the Surf Zone," Thesis, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 1977.

Keywords: *Surf zone, Breaking waves, Instruments*

Simultaneous measurements of sea surface elevation and onshore and alongshore water particle velocities were measured at three locations within the surf zone using two capacitance-type penetrating wave staffs and three two-component electromagnetic flowmeters. The probability density functions, pdf, for the sea-surface elevation were always highly positively skewed, whereas the pdf's for the velocities were both negatively and positively skewed. (DHL)

263. OLSEN, T.G., and VIUM, M.P., "Coastal Currents Generated by Breaking Waves," (in Danish) unpublished M.Sc. Thesis, Institute of Hydrodynamic and Hydraulic Engineering (ISVA), Technical University of Denmark, Lyngby, Denmark, 1974.

Keywords: *Breaking waves, Currents*

None available.

264. OPDAM, H.J., "Experimentele Fluoresceine Metingen Betreffende de Invloed van Gloven en Getij op de Storming Langs de Kust," Studierapport WWK71-5, DenHaag, RMS/WWK, Jan. Feb. 1971.

Keywords: *Measurements, Waves, Longshore current*

Experimental measurements were taken with the aid of Fluorescein to investigate the effects of waves and tide on longshore currents. (DHL)

265. O'ROURKE, J.C., and LEBLOND, P.H., "Longshore Currents in a Semicircular Bay," *Journal of Geophysical Research*, Vol. 77, No. 3, Jan. 1972, pp. 444-452.

Keywords: *Longshore currents, Theoretical model, Curved shorelines*

The theory of wave-induced longshore currents is extended to curved semicircular beaches. The currents are produced by the nonvanishing mean lateral thrust exerted by the waves through the divergence of their radiation stress in the surf zone. The equations are linearized and only the retarding effect of bottom friction is taken into account. The origin and influence of the various forcing terms are discussed. As a rule, the dominant forcing term is the one caused by the obliquity of incidence of the waves at the breaker line. A general solution is found for a semicircular bay of radius of curvature much greater than the width of the surf zone and linear beach slope. A specific example is worked out for a given form of the incident wave field at the breaker line, with small, but nonuniform angle of incidence and wave amplitude along that line. (Authors)

266. OSTENDORF, D.W., and MADSEN, O.S., "An Analysis of Longshore Currents and Associated Sediment Transport in the Surf Zone," Report 241, Massachusetts Institute of Technology, Department of Civil Engineering, Ralph M. Parsons Laboratory, Cambridge, Mass., Apr. 1979.

Keywords: *Surf zone, Longshore current models, Sediment transport*

Two momentum-based longshore current models and a preliminary longshore sediment transport model are derived, calibrated, and tested. The linear longshore current model predicts the relatively small longshore current induced by monochromatic, gravity waves of finite height and near-normal incidence breaking on a plane, impermeable, gently sloping bottom in the presence of a shore-normal jetty when the offshore wave height, wave period, wave angle, and water depth are known, along with the beach slope and roughness. The nonlinear model uses the same input, removes the assumptions of a relatively small current and near-normal wave incidence, and is valid only for uniform longshore conditions. (DHL)

267. OZAKI, A., SASAKI, M., and USUI, Y., "Study of Rip Currents: Experimental Observation of Nearshore Circulation on a Sloping Bottom," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 20, Dec. 1977, pp. 147-158.

Keywords: *Nearshore circulation, Rip currents, Laboratory experiments*

Rip current systems on a plane beach produced by a uniform wave train, normally incident on the beach, were investigated experimentally. The

flow pattern of the rip current depended on the rip spacing Ys and the width of the surf zone hB/tanb, where hB is the breaker depth, the overbar indicates the average, and tan b is the beach slope. For 20 varied velocity fields of wave-induced nearshore circulations, the nearshore circulation pattern was classified into 2 types fairly well by a dimensionless combination of these variables, a rip spacing parameter, YsO(-Ys/hB/tan b). As the rip spacing increases, the horizontal circulation changed its form from regular one to free jet. In the instability domain, the maximum spacing of rip currents was controlled by a dimensionless incident wave period TOg/hB, and was the rip spacing increased with increasing wave period TOg/hB. The smallest value of YsO was 1.39.

The flow velocity of rip current fell into zero at the breakpoint for minimum spacing of rip current. The rip velocity profiles along the rip current axis had a clear correlation with the rip spacing YsO. The location of the maximum rip velocity moves, with increasing the rip spacing YsO, from within the surf zone to the offshore side beyond the breakpoint, resulting in narrower rip width, and then the rip feeder currents were formed even in a deeper place beyond the breakpoint. (Authors)

268. PAWKA, S.S., "Study of Wave Climate in Nearshore Waters," *Proceedings, Ocean Wave Measurement and Analysis Symposium*, American Society of Civil Engineers, 1974, pp. 745-760.

Keywords: *Wave direction, Nearshore zone, Measurement system, Field studies*

Wind-generated waves provide a principal energy input and are the primary driving force for several nearshore processes including longshore currents. A specific knowledge of wave climate at a coastal location is required to predict coastal processes. A linear array of bottom pressure sensors (parallel to the coast) proved to be a practical and reliable system for the measurement of directional wave data. The energy spectra were parameterized by three variables: (a) period of maximum spectral density, (b) total peak energy, and (c) the band width. These parameters were sufficient for well-directed waves but further information is required to clarify nondirectional waves. Problems due to finite array size including poor resolution and "aliasing" gave some doubt to the usefulness of the raw spectra for input to computational models.

269. PAWKA, S.S., "Linear Arrays," *Proceedings, Nearshore Sediment Transport Study Workshop on Instrumentation for Nearshore Processes*, Scripps Institution of Oceanography, 1977, pp. 97-112.

Keywords: *Field experiments, Instrumentation*

Very poor resolution of waves propagating parallel to the array and total directional ambiguity for angles reflected through the array's axis are two disadvantages of linear arrays. Linear arrays should only be used in areas which have only two quadrants of possible wave approach and are of particular use when alined along a depth contour reasonably close to a straight segment of coastline. The following parameters may be varied in the design of a linear array: (a) relative spacing of sensors, (b) number of sensors, (c) total length of array, (d) depth of sensors, and (e) orientation of the array. There is no optimal arrays for systems with many sensors. The design should depend on the expected wave conditons. Along a plane contour beach a shallow array is desirable because the waves are refracted toward normal incidence, which is the angle of best resolution of the linear array.

270. PEREGRINE, D.H., "Equations for Water Waves and the Approximation Behind Them," *Waves on Beaches and Resulting Sediment Transport*, R.E. Meyer, ed., 1st ed., Academic Press, Inc., New York, 1972, pp. 95-121.

Keywords: *Wave theory, Shallow-water waves, Beach slope*

An excellent review based on order-of-magnitude approach of scaled variables to study the approximations behind the following equations: linearized wave equations; finite-amplitude, shallow-water equations; Boussinesq equations; Kortewet-DeVries equations; linearized long wave equations; and equations for variable depth. All equations are presented in their Eulerian form.

271. PEREGRINE, D.H., "Water-Wave Interaction in the Surf Zone," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974, pp. 500-517.

Keywords: *Surf zone, Analytical models, Nonlinear effects*

In the surf zone on beaches, there are strong effects which cannot be described by linear equations. This paper describes a number of wave interactions that can take place, using the simplest set of equations

that give an adequate qualitative description. The results are of value for comparison with detailed experimental measurements and for gaining understanding of surf zone processes. (Author)

272. PEREGRINE, D.H., "Fountains, Waterfalls, and Breaking Waves," *Euromech 122* 'Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Wave breaking, Physics*

This lecture aims to provoke discussion about our understanding of details in the breaking of water waves. Various features of a breaking wave are discussed and simple models which exhibit similar features examined. Some of these comparison are rather speculative but may provide a foundation for further, more precise work. (DHL)

273. PEREGRINE, D.H., and COKELET, E.D., "The Fluid Mechanics of a Breaking Wave," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Wave breaking, Mechanics, Physics*

Despite the very revealing recent work of Longuet-Higgins (1978) and Longuet-Higgins and Cokelet (1976, 1978) the dynamics of water motion at the moment a wave breaks and projects water forward of the crest are not understood. However, this motion is convincingly simulated in the numerical solutions of irrotational flow obtained by Longuet-Higgins and Cokelet. This paper drecribes results of detailed analysis of these solutions. (Authors)

274. PEREGRINE, D.H., and SVENDSEN, I.A., "Spilling Breakers, Bores and Hydraulic Jumps," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 540-550.

Keywords: *Wave breaking, Wave theory, Laboratory experiments*

On gently sloping beaches, almost all water waves break. After the initial breaking the water motion usually appears quite chaotic. However, for a moderate time, e.g., two or three times the descent time of the "plunge" in a plunging breaker, the flow can be relatively well organized despite the superficial view which is largely of spray and bubbles. If waves continue to break the breaking motion, or "white water" some becomes fully turbulent and the mean motions become quasi-steady. (DHL)

275. PHILLIPS, O.M., *The Dynamics of the Upper Ocean*, Cambridge University Press, London, 1969.

Keywords: *Water waves, Wave theory, Wave thrust, Radiation stress*

A unified treatment of the dynamical conservation equations for mass, momentum, and energy of waves superimposed on a variable current is presented in Chapter 3 of this book. The "radiation stress" concepts of Longuet-Higgins and Stewart are derived from fundamental principles.

276. PROVIS, D.G., and RADOK, R., eds., "Waves on Water of Variable Depth," *Proceedings, Symposium Australian Academy of Science*, Canberra, Australia, 1977.

Keywords: *Water waves, Beaches*

Twenty-six papers by leading water wave researchers in the world are presented, grouped in the following subjects: wave propagation in water of variable depth; tsunami generation and propagation; waves on beaches; waves and currents; wave in a rotating stratified medium; and long-period larotropic waves. In all cases, analytical, experimental and numerical works are discussed with shortcomings cited. Five papers about waves on beaches are of primary interest.

277. PUTNAM, J.A., MUNK, W.H., and TRAYLOR, M.A., "The Prediction of Longshore Currents," *Transactions of the American Geophysical Union*, Vol. 30, No. 3, June 1949, pp. 337-345.

Keywords: *Longshore current, Wave theory, Momentum principles*

Longshore currents are an important factor in beach erosion. A relationship is derived from theoretical considerations between the velocity of the longshore current and the height and period of the breaking waves, the angle between the breakers and the beach contours (assumed straight and parallel), and the beach slope in the breaker zone. Field observations and laboratory experiments support this relationship. (Authors)

278. REIMNITZ, E., et al., "Possible Rip Current Origin for Bottom Ripple Zones," *Geology*, Vol. 4, July 1976, pp. 395-400.

Keywords: *Rip currents, Farshore zone, Bed ripples*

Side-scan sonar records along the moderate- to high energy Pacific coast of Mexico show rippled-marked bands normal to the surf. These bands have been traced as far seaward as 1,500 meters from the beach in water as deep as 30 meters. There is strong evidence that these ripple bands are produced by rip currents. Earlier studies suggested that rip currents do not extend to the bottom beyond the breaker zone. The interpretations indicate that rip currents, probably those that develop under severe wave conditions, transport sediment, shape the bottom, and produce internal sedimentary structures much farther seaward than was previously believed. (DHL)

279. REINALDA, R., "Kuststromingen," *Proceedings Symposium Kustonderzoek, Project groep Kustonderzoek, Toegepast Onderzoeh Waterstaat,* Water loopbusding Laboratory, Delft, The Netherlands, 1977, pp. 8-11 (in Dutch).

Keywords: *Longshore currents, Wave theory*

Considerations on coastal currents induced by waves are presented.

280. SABATON, M., and HAUGEL, A., "A Numerical Model of Longshore Currents," Marine Forecasting, Predictability and Modeling in Ocean Hydrodynamics, *Proceedings of the 10th International Liege Colloquim on Ocean Hydrodynamics,* 1978, U.C.U. Nihoul, ed., Elsevier Oceanographic Series 25, 1979, pp. 183-195.

Keywords: *Longshore currents, Nearshore circulation systems, Numerical models*

A numerical model which permits computations of the longshore currents for any shape of shoreline and any bathymetry is introduced. The integration over the depth and the average over a wave period of the momentum and continuity equations leads to a system of equations identical to those of Saint-Venant in which supplementary stresses due to waves appear. (DHL)

281. SALLENGER, A.H., Jr., "Beach-Cusp Formation," *Marine Geology,* Amsterdam, The Netherlands, Vol. 29, No. 1-4, Jan. 1979, pp. 23-37.

Keywords: *Beach cusps, Edge waves*

Field experiments on beach-cusp formation were performed to document how the cuspate form develops and to test the edge wave hypothesis on the uniform spacing of cusps. These involved observations of cusps forming from an initially plane foreshore. The cuspate form was a product of swash modification of an intertidal beach ridge as follows. A ridge, cut by a series of channels quasi-equally spaced along its length, was deposited onto the lower foreshore. The ridge migrated shoreward with floodtide, while the longshore positions of the channels remained fixed. On ebbtide, changes in swash circulation over the ridge allowed the upwash to flow shoreward through the channels, and the channel mouths were eroded progressively wider until adjacent mouths met, effecting a cuspate shape. Measured spacings of cusps, ranging in size from J1 meter to K12 meter, agree well with computed spacings due to either zero-mode subharmonic or zero-mode synchronous edge waves. Edge wave-induced longshore variations in runup will cause water ponded behind a ridge to converge at points of low swash and flow seaward as relatively narrow currents eroding channels spaced at one edge wave for subharmonic edge waves. The channels are subsequently modified into cusp throughs. (AM)

282. SALLENGER, A.H., et al., "Profile, Wave, and Current Measurement System for the High Energy Nearshore," *Abstracts, Geological Society of America,* Cadilleran Section, Vol. 12, No. 3, 1980, p. 151.

Keywords: *Nearshore currents, Measurement systems, Field tests, Sleds*

Due to lack of field measurements, the mechanisms responsible for changes in the nearshore profile are not well understood. A new data acquisition system has been developed to provide measurements of the nearshore profile and of waves and currents that cause changes to the profile. Components of the mechanical system are a 10-meter-long mast mounted vertically on a 6-meter-long sled, a double-drum winch placed landward of the beach, and a line that runs from one drum of the winch around three blocks, which are the corners of a right triangle, to the other drum of the winch. One side of the triangle is oriented normal to the shoreline and extends 300 meters offshore. Along this side, the sled is pulled offshore by one drum of the wind and onshore by the other drum. As the sled moves along the transect, an infrared range finder measures the horizontal and vertical distances between the instrument and optical prisms mounted on top of the mast. These data are used to

plot a profile of the beach and nearshore. A pressure sensor and a two-axis electromagnetic current meter are mounted on the frame of the sled. These data are encoded on the sled and then telemetered to a receiving-recording station onshore. During field tests on Monterey Bay, California, the system operated successfully in breaking swell waves greater than 6 meters high and bottom currents greater than 3.5 meters per second. During this event, the 100-meter-wide surf profile was eroded an average of 0.3 meter. (Authors)

284. SASAKI, T., "Simulation on Shoreline and Nearshore Current," *Proceedings of the Speciality Conference on Civil Engineering in the Oceans, III*, American Society of Civil Engineers, 1975, pp. 174-196.

Keywords: *Nearshore circulations, Field experiments, Measurement systems*

The author has developed the following two simulation models on nearshore environments. The first model is for predicting shoreline deformation behind a detached breakwater placed parallel to the shoreline, and the second is for simulating currents in the nearshore zone under the influence of an aribtrary bottom topography. The former model was tested by the laboratory experiments of Horikawa and Koizumi (1974), and the latter was verified by the field observations of Sasaki (1974). (Author)

285. SASAKI, T., "Field Investigations of Nearshore Currents and a Gently Sloping Bottom," Report No. 3, Nearshore Environment Research Center, University of Tokyo, Tokyo, Japan, May 1977.

Keywords: *Nearshore circulations, Field observations, Measurement systems*

This report is essentially the Ph.D. dissertation of Sasaki (1974) in English. It includes an extensive review of Japanese research on nearshore processes up through 1974. Separate chapters are devoted to factors affecting nearshore current systems and field observation systems included reasons for development of the SIHELS and STEREO-BACS systems described elsewhere (Horiwaka and Sasaki, 1972). Primarily emphasis is on an analysis of mechanisms for rip current spacings and the empirical correlation of laboratory and field data for use in predicting cell circulation sizes. The field experiments at Ajigaura Beach are reviewed in detail and classified into five cases dependent upon whether rip currents or longshore currents are dominant. Finally, a numerical model for nearshore current systems is described which allows arbitrary bottom topography. Agreement between model and field-measured currents is only fair for two cases cited. A total of 15 assumptions needed in constructing the model are reviewed to explain reasons for mode-experiment discrepancies.

286. SASAKI, T., and HORIKAWA, K., "Nearshore Current System on a Gently Sloping Beach," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 18, Dec. 1975a, pp. 123-142.

Keywords: *Nearshore circulation, Measurement systems, Field studies, Japan*

The authors developed a new field observation system called STEREO-BACS by which simultaneous measurements of a special distribution on waves and currents in the nearshore environment can be obtained. This system was applied on Ajigaura Beach, Japan, and several analyzed results are presented. Also, field observations of infragravity low-mode edge waves to support the Infragravity Domain Hypothesis on nearshore currents concerning a gently sloping beach (Sasaki, 1974, 1975; Sasaki and Horikawa, 1975) are introduced. (Authors)

287. SASAKI, T., and HORIKAWA, K., "Nearshore Current System on a Gently Sloping Bottom," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 18, Dec. 1975b, pp. 123-142.

Keywords: *Nearshore circulation, Theoretical models, Field studies*

The authors found the existence of three domains on nearshore current systems by applying the surf similarity parameter (Iribarren No.) (Battjes, 1974) and the concept of infragravity waves (Suhayda, 1974). The previous two theories (Bowen and Inman, 1969; Hino, 1973) can be applied to two of the three domains, respectively, which correspond to steep and medium beaches. For the extra domain, there has been no theory, but from the analysis of field data, the authors are proposing a new hypothesis, the Infragravity Domain Hypothesis for it. From the many field observations of the velocity field taken by the BACS (Horikawa and Sasaki, 1972), several analyzed results are presented. (Authors)

288. SASAKI, T. O., and HORIKAWA, K., "Observation of Nearshore Current and Edge Waves," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 791-809.

Keywords: *Nearshore circulation, Field experiments, Measurement systems, Edge waves*

Nodal lines normal to the shoreline of infragravity low-mode edge waves in the nearshore zone were observed with 11 wave staffs simultaneously with the nearshore current spatial velocity field on a gently sloping beach. About five peaks were found in the energy spectrum and their frequencies agreed well with cutoff mode edge waves (Huntley, 1976). Based on the above observation, conceptual models of nearshore current patterns for the infragravity domain are proposed and general current patterns for the three domains are discussed by combining the horizontal patterns of Harris (1969) and the vertical patterns of Sasaki, et al. (1976). (Authors)

289. SASAKI, M., and OZAKI, A., "A Rip Current Theory Including the Effect of Wave Shoaling," *Proceedings of the 26th Japanese Conference on Coastal Engineering*, Japan Society of Civil Engineers, 1979.

Keywords: *Rip currents, Wave theory*

A theoretical investigation on the mechanism of rip current generation is developed. In the writers' former papers, the wave height outside the surf zone is considered to be constant. In the present paper, wave shoaling effects are directly introduced in the formulation of nearshore current system. This shoaling effect is considered to be extremely important in the near-breaking wave zone. Based on this fact, the wave height is put to be $H_0 + c/d$ where H_0 is deepwater wave height, c is constant and d is water depth. When the wave shoaling effect is taken into consideration, the bottom friction and eddy viscosity effect decrease according to the water depth increases. Due to this effect, the energy loss becomes milder and the nearshore current system spreads to the offshore direction. (Authors)

290. SASAKI, T.O., IGARASHI, H., and HARIKAI, S., "Nearshore Currents on a Partially Rocky Shore," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Nearshore circulations, Field studies, Japan*

Field investigations of nearshore currents were made at Haranomachi Beach, Japan, in 1978 using the tethered balloon camera technique. Of interest is the current behavior on this rocky coast as compared with smooth sandy beaches. The field conditions were also simulated in a laboratory wave basin. Bathymetric refraction was cited as responsible for wave energy concentration, breaker height variation, and rip current formation. It was concluded that current patterns were not much different than those found on sandy beaches with similar wave conditions.

291. SAVILLE, T., "Experimental Determination of Wave Set-Up," *Proceedings of the Second Technical Conference on Hurricanes*, American Society of Civil Engineers, 1961, pp. 242-252.

Keywords: *Wave setup, Laboratory study, Empirical model*

Wave setup may be defined as the superelevation of the water level caused by the action of waves alone. A small-scale test modeling approximately the profile off Narragansett Bay has confirmed that the roughly 3-foot difference in water level observed during the 1938 hurricane in relatively protected and unprotected areas was caused by wave setup. Additional laboratory tests have been made in an attempt to relate this setup empirically to slope and wave conditions.

In general, these tests have indicated a setup at the shoreline of about 10 to 15 percent of the wave height for profiles of 1 on 15 and gentler, with little or no setup at the shoreline for slopes steeper than about 1 on 6. The lack of setup for steep slopes has been confirmed with tests involving waves up to 5 feet high.

Tests have also been made with an offshore barrier with top elevations at and slightly below the stillwater level. These tests indicate considerably higher setups, the presence of the barrier sometimes doubling the setup at the shoreline. However, these tests involved a barrier across the entire width of the wave tank, and so did not permit any lateral flow out of the area of increased water level, as would probably occur in nature. Consequently this indicated barrier effect is possibly considerably exaggerated. (Author)

292. SAWARAGI, T., and IWATA, K., "On Wave Deformation After Breaking," *Proceedings of the 14th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1974, pp. 481-499.

Keywords: *Wave breaking, Laboratory experiments, Energy dissipation, Spectral analysis*

Waves will dissipate their energy rapidly after breaking. In this paper, the three factors (a) formation of a horizontal roller, (b) bottom friction, and (c) turbulence with air entrainment, which will contribute to the energy dissipation are dealt with experimentally and theoretically.

The horizontal roller formed by a plunging breaker is approximated as a Rankine-type vortex by experiments and it is calculated that 15 to 30 percent of wave energy is dissipated due to the formation of horizontal roller alone from a breaking point to a point of the roller disappearance.

A bottom shear stress due to a breaker is measured by the shear meter devised by the authors and it is clarified that the energy dissipation due to bottom friction is little.

Main part of the energy dissipation is taken to be caused by the turbulence with air entrainment. It is indicated that an incident monocromatic waves is transformed into a higher frequency wave due to the turbulence. Furthermore, a new basic equation for breaking waves with a turbulence term expressed by a Reynolds stress is presented. The theoretical curves computed numerically have a consistent agreement with the experimental results. (Authors)

293. *SAWARAGI, T., and IWATA, K., "Wave Spectrum of Breaking Wave," Proceedings of the 15th Conference on Coastal Engineering,* American Society of Civil Engineers, Vol. 1, 1976, pp. 580-594.

Keywords: *Wave breaking, Spectral Analysis, Wave theory*

By wave breaking, an incident monocromatic wave is transformed to a wave composed of its harmonic frequency waves inside a surf zone. Based on a dimensional consideration, the "-1 power law," the "-2 power law," the "-2/3 power law," and the "-1/2 power law" on the wave height spectrum, $H(f)$, are derived as sorts of equilibrium spectra. These spectra, with the exception of "-1/2 power law," are shown to agree with experimental data. (DHL)

294. SCHAEFER, G., III, "Probability Density Functions of Breaking Waves," M.S. Thesis, U.S. Naval Postgraduate School, Monterey, Calif., June 1978.

Keywords: *Surf zone, Wave breaking, Wave theory*

Waves in the surf zone are a highly nonlinear process which is evident by the appearance of secondary waves. The secondary waves appear as strong peaks in the period probability density functions corresponding to the first harmonic of the peak of the wave spectrum. The strong harmonic period peak is also reflected in the highly correlated height and velocity probability density functions. Breaking waves may be viewed as a gradation between two extremes. The period, height, and velocity probability density functions for spilling breakers generally were unimodal, whereas for plunging breakers strong bimodality was found. The joint probability density functions for periods and height of the breaking waves show high correlation (0.60 to 0.80) which indicates that greater wave periods are associated with larger breaker heights. (DHL)

295. SCHIFFMAN, A., "Energy Measurements in the Swash-Surf Zone," *Limnology and Oceanography,* Vol. 10, No. 2, Apr. 1965, pp. 225-260.

Keywords: *Surf zone, Measurements, Instruments, Field studies, Swash*

A technique has been devised for obtaining energy and sediment data in the swash surf zone of a beach. The instruments used are a bidirectional compression spring dynamometer and a rapid surface sand sampler that have been designed specifically for use shoreward of the breakers. On the basis of the information gathered to date, three distinct depositional environments have been defined inside the breaker zone. These are: (a) the swash zone, (b) the surf zone, and (c) a well-defined transition zone separating the first two. (Author)

296. SCHNEIDER, C., "Visual Surf Observations/Marineland Experiment," *Coastal Sediments 77,* American Society of Civil Engineers, 1977, pp. 1086-1099.

Keywords: *Surf zone, Field observations, Satellite correlations, Longshore currents*

As a part of the larger SEASAT-A experiment, it was decided to obtain wave and nearshore current data collected in accordance with techniques developed under the Littoral Environment Observation (LEO) Program. It was hoped that these visually obtained data could be compared with wave data obtained from both a waverider and a sea sled and that measurements obtained at one LEO site could be correlated with observations taken at similar nearby sites. Also, it was hoped that the validity of timewise extrapolation to determine surf conditions for the period before or subsequent to a given visual observation could be established. A number

of observers were recruited in an attempt to gather information on the influence of observer bias on the resulting data.

Surf conditions were observed to change appreciably over fairly short periods of time, a fact borne out by available instrument measurements. Consequently, the use of a single observational data set to characterize surf conditions over a 1-day period was not found to be a satisfactory representation. (Author)

297. SEYMOUR, R.J., ed., "Instrumentation for Nearshore Processes," *Proceedings, Nearshore Sediment Transport Study Workshop*, LaJolla, Calif., June 1977.

Keywords: *Instrumentation, Data Acquisition, Measurement systems*

This compilation of workshop papers are grouped in order of their primary objectives. The objectives were to: (a) determine the present capabilities for measuring and recording nearshore parameters related to sediment transport; (b) determine the specific needs of the Nearshore Sediment Transport Study for instrumentation; and (c) discover areas requiring further development to meet the needs of the Nearshore Sediment Transport Study.

298. SEYMOUR, R.J., and HIGGINS, A.L., "A Slope Array for Estimating Wave Direction," *Proceedings of the Nearshore Sediment Transport Study Workshop on Instrumentation for Nearshore Processes*, Scripps Institution of Oceanography, 1977, pp. 133-142.

Keywords: *Measurement systems, Field studies, Wave direction*

The concept of measuring wave directional properties from a knowledge of the time history of sea surface slope is employed in shallow water using a fixed, four-gage rectangular array. The theory, method of analysis, and error estimated are presented. The surface slopes are related to the shoreward-directed momentum flux (S_{xy}) due to ocean waves. Thus a "direct" measurement of S_{xy} and wave angle is available. Experimental verification is provided from laboratory tests with very good agreement noted.

299. SHADRIN, I. F., "The Possibility of Predicting Longshore Currents in Tideless Seas," *Dynamics and Morphology of Sea Coasts*, V.V. Longinov, ed., Academy of Sciences of the USSR, *Transactions of the Institute of Oceanology*, Vol. 48, 1961, pp. 350-364.

Keywords: *Longshore currents, Shoaling waves, Circulation, Wave energy*

Longshore bars and rip current effects are included in a mean longshore current velocity formula proposed which is based primarily on field measurements on the Anapa coast facing the Black Sea. Besides the usual breaker angle, height and period, the equation includes various horizontal distances to the offshore bars from the shoreline. See Horikawa and Sasaki (1968) and Horikawa (1978) for further details.

300. SHARAF, E.S.H., "Longshore Sand Transport in the Surf Zone Along the Mediterranean Coast," *Limnology and Oceanography*, Vol. 19, No. 2, Mar. 1974, pp. 182-189.

Keywords: *Longshore currents, Field measurement, Egypt*

From 1960 to 1969 a detailed survey of current pattern was carried out at Rosetta and Danietta estuaries of the Nile Delta and the outlets of the coastal lakes. In 1968 littoral drift observations were made using fluorescent tracers at Ra'sal-Barr. A coastal survey program in progress since 1971 at fixed locations along the coast has evaluated the dynamics of coastal erosion. The average littoral current is 35 centimeters per second at Burullus Inlet, 40 at Rosetta exit, and 28 at Danietta. The coastal surveys have shown coastal processes, including erosion and deposition, to be different in different stretches along the deltaic coast from Rosetta to Port Said, indicating that more detailed studies over many years will be necessary. (Author)

301. SHEPARD, F.B., "Longshore Current Observations in Southern California," TM-13, U.S. Army, Corps of Engineers, Beach Erosion Board, Washington, D.C., Jan. 1950.

Keywords: *Longshore currents, Rip currents, Field studies*

Under Navy contract N60ri-111 at Scripps Institution of Oceanography currents were measured in the surf zone at frequent intervals throughout a year at a series of stations along the southern California coast from the Mexican border to Newport. The study of the data from these measurements shows that the dominant currents in the area are to the south, evidently in response to the direction of approach of the principal wave trains. North currents indicative of Southern Hemisphere storms prevail during a large part of the summer and fall. The feeders of rip currents were found to be important causes of longshore currents, particularly in areas with considerable submarine relief, but also in areas with straight

beaches and parallel contours. Strong longshore currents exist even during times when large waves approach with their orthogonals essentially normal to the beaches. The importance of currents moving along the shore away from points of wave convergence was demonstrated by the year's investigation and has been confirmed subsequently by studies in the La Jolla area. (Author)

302. SHEPARD, F. B., and INMAN, D.L., "Nearshore Water Circulation Related to Bottom Topography and Wave Refraction," *Transactions of the American Geophysical Union*, Vol. 31, No. 2, April 1950, pp. 196-212.

Keywords: *Nearshore circulation, Rip currents, Longshore currents, Field studies*

The nearshore circulation in the vicinity of Scripps Beach has been measured by means of very simple devices. It has been found that this circulation is controlled to a large degree by the wave convergence and divergence resulting from the diversified submarine relief outside this gently curving shoreline. The position of rip currents is similarly related to the points of wave convergence and divergence. The existence of strong longshore currents flowing against the direction of wave approach is established. The development of large eddies with vertical axes is discussed. Also the pulsating nature of outflowing rip currents is related to alternating groups of high and low breakers. (Authors)

303. SHEPARD, F.B., and INMAN, D.L., "Nearshore Circulation," *Proceedings of the First Conference on Coastal Engineering*, Council on Wave Research, Vol. I, 1951, pp. 50-59.

Keywords: *Nearshore circulation, Longshore currents, Field studies*

In 1945 a program of field observations was initiated to study the nearshore currents in relation to a variety of coastal types and submarine configurations. Operations extending over a period of 1 year involved measurement of currents inside the breakers at 63 stations from the United States-Mexican boundary to Newport, California. The observations were repeated approximately every 12 days. Subsequently, the shallow waters adjacent to individual beaches representative of various types of environment have been studied intensively. This work has included a beach with adjacent submerged ridge and canyon topography, two straight beaches with parallel bottom contours, and one beach at the head of a crescentic bay. In addition the effects of jetties, piers, and points have been investigated. During this work currents inside and outside the breaker zone were investigated. Most of the observations were made in southern California, but studies along many other coasts of the United States and in the Hawaiian Islands indicate that the results have a general application. (Authors)

304. SHEPARD, F.B., and SAYNER, D.B., "Longshore and Coastal Currents at Scripps Institution Pier," *Bulletin of the Beach Erosion Board*, Vol. 7, No. 1, U.S. Army, Corps of Engineers, 1953, pp. 1-9.

Keywords: *Longshore currents, Field studies*

All field experiments showed that longshore current was largely confined to the surf zone and that a substantial velocity variation could exist across the surf zone. This study compiles the results of 5 years (800 days of measurements) taken at three locations along the 1,000-foot pier at Scripps. One was at the end of the pier outside the surf zone, one just outside the breakers, and one inside the surf zone. "They established that the currents inside and outside the surf zone were governed by the same mechanisms, i.e., they were correlated and related to wave height and direction. The currents varied considerably from offshore to the beach, the average current velocity inside the surf zone was 1.0 foot per second compared with about 0.2 foot per second outside the breakers.

305. SHEPARD, F.B., EMERGY, K.O., and LaFOND, E.C., "Rip Currents: A Process of Geological Importance," *Journal of Geology*, Vol. 41, No. 4, May 1941, pp. 337-369.

Keywords: *Rip currents*

Rip currents are defined as seaward-moving streaks of water which return the water carried landward by waves. These currents are believed to be an almost universal accompaniment of large waves breaking on an exposed coast.

Unlike the largely hypothetical undertow, rip currents flow principally at and near the surface. They attain velocities up to at least 2 miles per hour and extend on occasions for 1,000 feet or more from the shore. Geologically, the currents are of importance, since they carry a suspended load of fine sediment out from the shore. Small channels in the sand are produced by the flow in the nearshore parts of the rip currents.

The development and changes of these channels have been investigated. The strong outflow of current and the presence of the channels along the bottom constitute a serious danger to inexperienced swimmers. (Authors)

306. SHEPARD, F.P., "Undertow, Rip Tide or Rip Current," *Science*, Vol. 84, Aug. 1936, pp. 181-182.

Keywords: *Rip currents*

Author argues against use of term undertow on scientific grounds based on field measurements of these currents. He introduced for the first time the term "rip current" to describe the rapidly seaward-flowing currents that were thought responsible for many drownings of ocean swimmers at that time.

307. SHIMANO, T., HOM-MA, M., and HORIKAWA, K., "Effect of a Jetty on Nearshore Currents," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 1, 1958, pp. 45-58.

Keywords: *Nearshore circulation, Laboratory experiments, Japan*

An early laboratory study which used paper floats to qualitatively study currents and circulation patterns induced by waves near a groin. Dimensional analysis methods employed in an attempt to correlate the measurements of current speed, wave height, angles, etc. Some sediment movements observed.

308. SKOVGAARD, O., JONSSON, I.G., and OLSEN, G.O., "Calculation of Longshore Current Patterns," *Euromech 102* (Breaking Waves: Surf and Run-up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Longshore currents, Theoretical model, Wave thrust, Eddy viscosity models*

Classic momentum conservation theory is applied to predict longshore current profiles on a beach of arbitrary variation (but parallel) in depth contours and a given bottom roughness. Input data are regular waves at some angle and some arbitrary starting depth. Different expressions are used to model the eddy viscosity in the seaward side of the breakers (the nonbreaking zone) and in the surf zone. The results when compared with laboratory and field measurements produce a more realistic profile in the tail region outside the breakers. Complete details can be found in a subsequent Technical University of Denmark publication.

309. SMITH, D.A., "Radiation Stress Effects on Wave Set-Up in the Surf Zone," M.S. Thesis, University of London, Imperial College, Department of Civil Engineering, Sept. 1974.

Keywords: *Wave setup, Wave theory, Laboratory experiments*

310. SONU, C.J., "Study of Shore Processes with Aid of Aerial Photogrammetry," *Photogrammetric Engineering*, Vol. 30, No. 6, Nov. 1964, pp. 932-941.

Keywords: *Coastal processes, Measurement techniques, Instrumentation, Aerial photography*

Difficulties in the study of coastal engineering arise from the inadequate means of investigation and the content of data thus obtained. Basic requirements call for coverage of coastal mechanism as simultaneous recordings of waves, currents, topographies, etc., with alongshore as well as perpendicular extensions. A new method, as proposed in this paper, is based on the use of aerial photogrammetry. This paper reviews the historical background of the use of aerial photogrammetry for purposes of coastal investigation. Discussion is presented on the advantages of aerial photographic method in the study of shallow-water topographies, rhythmic reliefs. Technical problems and suggestions are made with an outlook to develop aerial photographic methods as routine instruments for coastal investigation. (Author)

311. SONU, C.J., "Tethered Ballon for Study of Coastal Dynamics," *Proceedings of the Symposium on Earth Observations from Ballons*, American Society of Photogrammetry, 1969, pp. 91-102.

Keywords: *Nearshore currents, Measurement systems, Instruments, Field studies*

A device consisting of a homemade polyethylene balloon and a radio-controlled 35-millimeter camera succeeded in providing time-lapse photographs of wave-generated nearshore currents. The quality of the photographs was excellent and yielded a wealth of information. The wide field coverage and detail were of particular advantage in interpretation. A tethered balloon carrying a camera or other specialized sensors can be adapted to monitor various physical phenomena in coasts

and estuaries. Possibilities exist for the use of such a system for acquisition of quantitative data. (Author)

312. SONU, C. J., "Velocities in a Nearshore Circulation Cell," *Transactions of the American Geophysical Union*, Vol. 50, No. 4, Apr. 1969a, p. 192.

Keywords: *Nearshore circulation, Field studies, Instrumentation, Rip currents*

Velocities in a nearshore circulation cell, both in plan view and across the depth, were measured by using a ducted impeller current meter on a sandy coast of northwest Florida. Water movement between adjacent rips was found to be directed predominantly shoreward because of translation of waves over a shallow bed, but was basically oscillatory. Water movement of sustained direction - one that may be called "current" - occurred in the feeder and rip channels. There was an indication that the position of peak velocity across the depth rose steadily toward the surface with distance seaward along the rip channel - a feature also recognized by Shepard and Inman. Velocity fluctuations with time were complex. Similar frequencies appeared both in the velocity and water level fluctuations, with a timelag on the order of 10 seconds between them. Results of the cross-spectral analysis are discussed. (Author)

313. SONU, C. J., "Balloon-Borne Platform for Study of Nearshore Current System," *Transactions of the American Geophysical Union*, Vol. 50, No. 4, Apr. 1969b, p. 192.

Keywords: *Nearshore circulation, Longshore currents, Field studies, Measurement system, Instrumentation*

Time-lapse aerial photographs were taken of the movement of dye patches in the longshore current system by means of a tethered balloon suspending a remote-controlled camera at an altitude of approximately 350 feet. The balloon, having an aerofoil cross section and measuring 750 cubic feet in volume, was constructed of a polyethylene sheet (4 mils), which was heat-sealed and reinforced along the seam with pressure-sensitive tape. The camera, a Nikon F equipped with an automatic back, was triggered either by radio signal or through a telephone cable connected to a switch on the ground. The balloon provided a buoyancy lift of 54 pounds, while the total payload, including both the camera capsule and tethers, weighed 36 pounds. Photographs thus obtained disclosed activities of rip currents and related circulation cells in much greater clarity and detail than could be obtained from ground observation. Other information of importance - i.e., distribution of wave crests in the general nearshore zone, shoreline configuration, bottom relief in the area of onshore mass transport by translatory waves, rip and feeder channels, and giant ripple marks in their bed, was also contained in the photographs. Improvements are proposed so that the system may aid in acquisition of quantitative data on shore dynamics. (Author)

314. SONU, C. J., "Field Observance of Nearshore Circulation and Meandering Currents," *Journal of Geophysical Research*, Vol. 77, No. 18, June 1972, pp. 3232-3247.

Keywords: *Nearshore circulation, Field studies, Measurement techniques, Instrumentation, Longshore currents*

Field observations were made of wave-induced nearshore circulations and meandering longshore currents on an undulatory surf zone bed, under the action of uniform incident waves. Circulations were associated with normal wave incidence; meandering currents were associated with oblique-wave incidence. The transport in the observed circulations generally agreed with Bowen's (1967) linear theory based on the concept of radiation stress (Longuet-Higgins and Stewart, 1962, 1964), provided that a friction coefficient C = 0.014 was assumed. The longshore current near the slope line moved from a shoal to a depression as predicted, but this movement was also directed from an area of high waves to one of low waves, which is different from the case of a circulation driving by nonuniform breaker heights on the bar. Spilling breakers over the shoal underwent greater energy dissipation than plunging breakers in the rip current. Observed streamlines were narrow in the outflow and broad in the inflow, a characteristic that was probably associated with a nonlinear mechanism arising from a steep depression in the rip channel, as previously explained by Arthur (1962). These circulations were pulsational unlike the circulations of a steady-state solution. Occasional strong outflows at beat frequencies caused water to escape from circulation. For a given surf zone undulation, breaking over the inner bar was essential to the formation of a circulation, and the intensity of breaking, controlled by tide, corresponded with a proportionally stronger circulation. Thus circulations were generally stronger during low tide than during high tide. Low rip current velocities at high tide fluctuated with incoming swells, whereas high velocities at low tide tended to fluctuate at surf beat frequencies. In proportion to increasing rip velocities, the rip

pulsation tended toward lower intervals. Mean surface slopes caused by wave setup and setdown agreed with trajectories of neutral-density balls released in the circulation. Meandering currents associated with oblique-wave incidence could be explained as a combined effect of circulation cells and parallel longshore flows. (Author)

315. SONU, C.J., "Computer Prediction of Nearshore and Surf Zone Statistics: Final Report," Report TC-394, Tetra Tech, Inc., Pasadena, Calif., Sept. 1975.

Keywords: *Longshore currents, Wave breaking heights, Computer prediction, Naval warfare*

For the purpose of aiding in the strategic planning of naval inshore warfare operations, a study has been performed to develop prediction technology for shallow-water waves, breakers, and longshore current velocities, using the visually observed deepwater wave statistics as input. Computer programs, code-named BREAKM and STATBR, and various nomographs have been developed to permit predictions for both physical magnitude and long-term statistics. Information display formats have been developed with a view to permitting speedy review of various key physical parameters and comparison between adjacent regions. Predicted results compare reasonably well with visually observed nearshore data, provided that a tolerable amount of discrepancy exists due partly to local conditions not accounted for in the prediction, partly to the built-in safety margin in the prediction, and partly to the limitations inherent to the state-of-the-art. (Author)

316. SONU, C.J., "Mixing in the Nearshore Circulation System," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, 1976.

Keywords: *Nearshore circulations, Lateral turbulent mixing, Field studies, Mixing processes*

Mixing characteristics in the nearshore circulation system were investigated through detailed field measurements of surf zone topography, circulation velocity field, breaking waves, and dye dispersion. Depending upon the surf zone topography and breaker incidence angle, two distinctive cases of circulation arose, exhibiting different mixing patterns. One was a system of closed circulation cells associated with a perpendicular breaker incidence angle against the shore. Under this condition, breakers contributed turbulent diffusion in the surf zone while the rip current caused dispersion due to shear effect in the velocity profile and advection through offshore transport.

The other case was a meandering current associated with oblique breaker incidence angles. Under this condition, the predominant mixing process consisted of turbulent mixing in the surf zone due to breakers, alongshore advection between adjacent cells through the meandering streamlines involving oblique rip currents and onshore mass transport, and recirculation within individual cells. The predominant mixing component was in the offshore and onshore directions in the case of closed circulation, and in the alongshore direction in the case of meandering current. (Author)

317. SONU, C.J., and JOHANNES, L.V., "Systematic Beach Changes on the Outer Banks, North Carolina," *Journal of Geology*, Vol. 79, No. 4, July 1971, pp. 416-425.

Keywords: *Wind-generated currents, Field measurements*

From Wiegel (1977, p. 147): "Few papers have presented data on measurements in the surf zone and there is almost no data for the case of waves and currents generated by winds even though there is evidence that it is this combination that is important to the movement of sand *off* the beach."

318. SONU, C.J., McCLOY, J.M., and McARTHUR, D.S., "Longshore Currents and Nearshore Topographies," *Proceedings of the 10th Conference on Coastal Engineering*, American Society of Civil Engineers, 1967, pp. 524-544.

Keywords: *Mean longshore currents, Field measurements, Theory*

Validity of seven analytical formulas as well as linear and nonlinear multiple regressive schemes was tested using field data from the Outer Banks, North Carolina. Generally, agreement proved unsatisfactory. Field experiences indicate that the longshore current is a velocity field consisting of a multitude of velocity vectors whose basic pattern varies depending upon the regimes of wave-current topography interaction. The need to recognize topography as a responding variable as well as a process variable in the physical scheme of longshore current is emphasized. (Authors)

319. STIASSNIE, M., and KROSZYNSKI, U.I., "On the Dependence of Extreme Values for Breaker-Line Angle and Longshore Current, on the Angle of Wave Approach in Deep Water," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Longshore current, Theoretical models, Wave thrust*

In the framework of linearized wave theory, using the classical wave breaking criterion and longshore current formula, the following two extreme conditions are analytically derived: The maximum angle (α) (b_{max}) between the breaker line and the shoreline occurs when the angles (α)(o) between wave fronts in deep water and the shoreline is about 66°; maximum longshore current velocities U(max) are obtained when the above-mentioned angle (α)(o) is about 58°. (DHL)

320. STIASSNIE, M., and KROSZYNSKI, U., "Extreme Values of Breaker Direction and Longshore Current," *Journal of the Waterway Port, Coastal and Ocean Division*, Vol. 105, No. WW3, Aug. 1979, pp. 331-336.

Keywords: *Longshore currents, Wave theory*

Classical wave hydromechanics (refraction theory, wave shoaling, etc.) and empirical wave breaking criteria are used together with radiation stress theory for the longshore current velocity to study analytically the values of deepwater wave angle α_o which create extreme angles at the breaker, α_b and maximum currents. The following results are valid for linearized wave theory:

(a) α_o occurs when α_o is 66°, and
(b) maximum longshore current velocity is obtained when α_o is about 58°.

Details are given of the derivation and assumptions required.

321. STIVE, M.J.F., "Velocity and Pressure Field of Spilling Breakers," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Wave breaking, Laboratory experiments, Velocity and pressure fields*

Detailed and precise measurements of the internal velocity and pressure fields were made in laboratory waves shoaling and breaking on a beach to directly estimate the momentum and energy flux. This is in direct contrast to most surf zone energy dissipation studies which solely rely on measurements of wave height variations. A laser-Doppler velocity measured velocity components in the horizontal and vertical directions simultaneously. Internal pressures were measured with a differential pressure transducer. The time-series signals were employed directly to calculate the excess flux of momentum due to the waves (radiation stress) using the measured u, p and surface variations, η. The mean water level, $\bar{\eta}$ variations both outside (setdown) and inside (setup) the surf zone were calculated from the radiation stress measurements and compared with those calculated from the measured wave height using the usual linear wave theory. The wave height method produced excessive setdown and more setup than that calculated from direct internal velocities and pressures. Both calculations gave larger setup than the mean $\bar{\eta}$ values measured during the experiments.

322. SUHAYDA, J.N., and PETTIGREW, N.R., "Observations of Wave Height and Wave Celerity in the Surf Zone," *Journal of Geophysical Research*, Vol. 82, No. 9, Mar. 1977, pp. 1419-1424.

Keywords: *Surf zone, Field measurements, Energy, Celerity*

Observations of wave crest elevation, wave trough elevation, and wave celerity have been made in the surf zone on a natural beach. A series of 22 wave poles having vertical gradations of 7 centimeters (nearshore) and 11 centimeters (offshore) were placed across the surf zone from outside the breakpoint to the swash zone. Movements of 10 individual waves all having a breakpoint within one wave pole spacing of each other have been photographed, and the data on wave height changes and wave speed changes have been analyzed. Wave celerity within the surf zone, given as a ratio M to solitary wave celerity, shows a systematic increase of wave speeds near the breakpoint to a peak of M thence a decrease farther shoreward to M=0.8, and finally a second increase where M>1. Wave height decay after breaking follows the theory of turbulent dissipation recently presented by Sawaragi and Iwata (1974). The wave height-to-water depth ratio within the surf zone is a function of distance from the breakpoint and ranges from 2.0 to 0.6. The results indicate that the use of linear and nonlinear nonviscous wave theories to quantify surf zone wave characteristics is misleading insofar as quantitative prediction is concerned. (Authors)

323. SVENDSEN, I.A., and HANSEN, J.B., "Wave Set-Down Near Breaking," Progress Report No. 41, Institute of Hydrodynamics and Hydraulic Engineering, Technical University of Denmark, Lyngby, Denmark, Dec. 1976.

Keywords: *Wave thrust, Wave setdown, Theoretical model*

The wave setdown on a coast is considered with particular emphasis on the conditions as the wave approaches breaking. It is shown that a number of formulas which are consistent with the cnoidal approximations can be derived for the wave setdown.

By comparison with experiments it is shown that one of these predicts the setdown quite satisfactory to the point where the wave breaks. (Authors)

324. SVENDSEN, I.A., MADSEN, P.A., and HANSEN, J.B., "Some Results for Waves in the Surf Zone," *Euromech 102* (Breaking Waves: Surf and Run-up on Beaches), University of Bristol, Bristol, England, July 1978a.

Keywords: *Surf zone, Bore theory, Physics and mechanics*

At some distance shorewards from the breaking point, the wave re-form in the shape of a (periodic) bore, and this region is the primary object for the present study. The periodic bore is first compared with the classical bore or the hydraulic jump and important similarities and differences are pointed out. In the hydraulic jump the assumptions of constant velocity in depth and static pressure lead to quite reliable results. It is shown both by physical arguments and by analytical results that due to the above-mentioned differences in the periodic bore, the velocity is not constant and the pressure may not be static. The analytical results are obtained by assuming two different types of velocity and pressure profiles, requiring conservation of mass and momentum. (DHL)

325. SVENDSEN, I.A., MADSEN, P.A., and HANSEN, J.B., "Wave Characteristics in the Surf Zone," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978b, pp. 520-539.

Keywords: *Surf zone, Wave theory, Wave heights*

The equations describing conservation of mass, momentum, and energy in a turbulent free-surface flow are derived for a control volume extending over the whole depth. The effect of the turbulent surface oscillations are discussed but neglected in the following analysis, where the equations are applied to the energy balance in a surf zone wave motion. This leads to results for the wave height variation and the velocity of propagation. The results cannot be reconciled completely with measurements and the concluding discussion is aimed at revealing how the model can be improved. (Authors)

326. SVERDRUP, H.U., and MUNK, W.H., "Empirical and Theoretical Relations Between Wind, Sea, and Swell," *Transactions of the American Geophysical Union*, Vol. 27, No. 6, Dec. 1946, pp. 828-836.

Keywords: *Wave transformation, Shallow-water waves, Breakers*

The relations are given which govern the transformation of waves in shallow water and upon which practical methods for forecasting breakers and surf have been based. For each relation the theoretical background is stated, together with a brief summary of empirical evidence. The discussion includes examples of the application of some of the relations. (Authors)

327. SZUWALSKI, A., "Littoral Environment Observation in California," MP2-70, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Washington, D.C., Feb. 1968.

Keywords: *Longshore currents, Wave statistics, Data collection systems, Field observations*

This report describes the Littoral Environment Observation (LEO) Program, and assembles in one paper the data collected under the program February-December 1968. LEO is a cooperative effort of the State of California and the Corps of Engineers to collect littoral data. Beach characteristics recorded are: foreshore slope, width and elevation of berm, presence of cusps, and sediment samples. Sea variables include tide level, wave height, period, and direction, type of breakers, direction and velocity of littoral currents, presence of rip currents and water temperature. Wind velocity and direction are recorded, and panoramic photographs are obtained. The data collected are being used as a base to analyze physical characteristics of the shoreline and littoral processes affecting it. (Author)

328. TAIT, R.J., "Edge Wave Mode and Rip Current Spacing," Ph.D. Dissertation, University of California, San Diego, Calif., 1970.

Keywords: *Edge wave, Wave theory, Rip currents, Modeling*

On straight, plain beaches with essentially normal wave incidence, nearshore circulation cells and rip current spacings are determined by the dominant edge wave mode. A predictive model was developed by extending the edge wave theory of Ursell (1952). The wave breaking location was made the additional boundary condition where any onshore-offshore velocity component is zero. Laboratory tests verified the model for slopes between 0.070 and 0.100. Field data extended the model range to real beaches with smaller and larger slopes. Limitations for use of the model are presented so that errors in predicted rip current spacings are said to be less than ±20 percent.

329. TAIT, R.J., and INMAN, D.L., "Low Frequency Resonance in the Surf Zone," *Transactions of the American Geophysical Union*, Vol. 50, No. 4, Apr. 1969, p. 191.

Keywords: *Surf zone, Energy transfer, Wave theory*

A transfer of energy to lower frequencies occurs when groups of waves shoal and break on a sloping beach. The transfer is associated with the radiation stress of the wave groups and produces an additional long wave having the frequency of the group (or beat). Since this long wave does not break, its energy is only slightly dissipated in the process of run-up and reflection. The theory of low-amplitude waves on an inclined plane suggests that resonance can be expected for certain combinations of slope and length in the nearshore bathymetry. Further, because the set-down due to the radiation stress changes abruptly near the breakpoint, resonance is enhanced if the surf zone width equals an odd-quarter wavelength, $(2n+1)L/4$, of the beat wave. The conditions favoring energy transfer and resonance have been investigated in the field and in the laboratory, and both verify the transfer of energy to lower frequencies and the enhancement of runup at certain frequencies. (Authors)

330. TAM, C.K.W., "Dynamics of Rip Currents," *Journal of Geophysical Research*, Vol. 78, No. 12, Apr. 1973, pp. 1937-1943.

Keywords: *Rip currents, Nearshore currents, Wave theory*

The dynamics of rip currents is investigated using a set of shallow-water equations with a horizontal eddy viscosity term. A boundary layer analysis is introduced based on the observed fact that rip currents are rather narrow. Similarity solutions of the model equations are found which seem to give reasonable representations of the velocity profile and other characteristics of rip currents. The mechanisms that are believed to be responsible for the formation of rip heads are studied. The turning of rip currents due to the longshore momentum carried by the entrained fluid is analyzed. (Author)

331. TELEKI, P.G., MUSIALOWSKI, F.R., and PRINS, D.A., "Data Acquisition Methods for Coastal Currents," *Proceedings of the Specialty Conference on Civil Engineering in the Ocean/III*, American Society of Civil Engineers, 1975, pp. 1190-1210.

Keywords: *Nearshore currents, Measurement systems, Field tests*

Design criteria for the type and location of coastal engineering structures depend heavily on the understanding of nearshore processes and the evaluation of the ranges of significant parameters such as waves, currents, and sediment transport. Gaging of these parameters in and around the zone of breaking waves has been difficult for the lack of rugged implements and instruments, mobility and adequate experimental design.

In answer to some previous shortcomings, a Towed Oceanographic Data Acquisition System (TODAS) has been developed for collection of nearshore current and wave data. The sensors are located on a mobile platform (the sea sled) and data acquired by them are telemetered to shore and digitally recorded. TODAS was designed for the real time evaluation of the characteristics of flow between shore and a depth of 30 feet, and because it is mobile and battery operated it can be used to survey reasonably large areas at even remote locations. Two experimental designs were developed for TODAS; a mobile mode for the moinitoring of waves and longshore currents in shore-normal profiles, and an in situ mode in which Eulerian and Lagrangian techniques of flow measurement are combined. In the latter, fixed point metering is supported by aerial photography and concentration measurements of dispersing dye plumes. (Authors)

332. TELEKI, P.G., MUSIALOWSKI, F.R., and PRINS, D.A., "Measurement Techniques for Coastal Waves and Currents," MR76-11, U.S. Army, Corps of Engineers, Coastal Engineerins Research Center, Fort Belvoir, Va., Nov. 1976.

Keywords: *Current meters, Current measurements, Sea sled, Telemetry, Wave gages*

A Towed Oceanographic Data Acquisition System (TODAS) consisting of a towed platform (sea sled) with current meters and a wave gage has been developed for collection of information on nearshore currents and waves. Data acquired by the sensors are telemetered to shore and digitally recorded. TODAS is used for real time evaluation of flow characteristics between shore and a depth of 9.14 meters (30 feet); this mobile battery-operated system can be used at remote locations. The system has been used principally in two experimental designs: (a) Monitoring the distribution of longshore currents in shore-normal profiles, and (b) a combination of Eulerian-Lagrangian experiments where fixed-point metering is supported by aerial photography of diffusing dye plumes and concentration measurement of the dye tracers. (Authors)

333. THORNTON, E.B., "Longshore Current and Sediment Transport," Technical Report No. 5, Department of Coastal and Oceanographic Engineering, University of Florida, Gainesville, Fla., Dec. 1969.

Keywords: *Longshore current, Velocity distribution, Laboratory and field measurements*

A simplified model assuming steady waves, straight and parallel bottom contours, but arbitrary bottom profile, linear wave theory, and spilling breakers across the surf zone is derived to describe the longshore current velocity profile as induced by shoaling waves approaching the beach at an angle. The equation of mass and motion (momentum) conservation and separated into steady and unsteady components to second-order wave amplitude. The expression for longshore current developed is based on the alongshore component of the excess momentum flux (radiation stress) due to the presence of unsteady wave motion. The work is parallel to Bowen (1967) but differs quantitatively. The wave-induced currents are found to be primarily confined to the area inside the breaker line, i.e., the surf zone. The expression for longshore current velocity profile is investigated for varying bottom profiles (theoretically) to evaluate the physical significance of different frictional resistance terms. Wave setdown and setup are included in the formulation.

Author indicates comparison with experiments results from the laboratory and field show that if the assumed conditions are approximately fulfilled, the predicted results compared quite favorably.

334. THORNTON, E.B., "Longshore Current and Sediment Transport," Ph.D. Dissertation, University of Florida, Gainesville, Fla., 1970a.

Keywords: *Longshore current, Theoretical model, Field experiments*

A theoretical expression for the distribution of longshore current across the surf zone is derived using principles of radiation stress. The basic assumptions are steady, time-averaged waves; straight infinite beach profile but of arbitrary shape; linear wave theory and spilling breakers. Wave setdown and setup are included in the formulation. A quadratic bottom friction formulation is employed and lateral, turbulent mixing is also included. Theory is compared with experimental results of others from the laboratory and the author's own field measurements. The results are said to compare "...quite favorably." Sediment transport theory and field data are also described.

335. THORNTON, E.B., "Variation of Longshore Current Across the Surf Zone," *Proceedings of the 12th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1970b, pp. 291-308.

Keywords: *Longshore current, Theoretical model, Wave thrust, Field experiments*

The wave-induced longshore current variation across the surf zone is described for a simplified model. The basic assumptions are that the conditions are steady, the bottom contours are straight and parallel but allow for an arbitrary bottom profile, the waves are adequately described by linear theory, and that spilling breakers exist across the surf zone. Conservation equations of mass, momentum, and energy, separated into the steady and unsteady components, are used to describe second-order wave-induced phenomena of shoaling waves approaching at an angle to the beach. An expression for the longshore current is developed, based on the alongshore component of excess momentum flux due to the presence of unsteady wave motion. Wave setup and setdown have been included in the formulation. Emphasis in the analysis is placed on formulating usable predictive equations for engineering practice. Comparison with experimental results from the laboratory and field shows that if the assumed conditions are approximately fulfilled, the predicted results compare quite favorably. (Author)

336. THORNTON, E.B., "Review of Status of Energetics and Momentum Fluxes in the Surf Zone: Field Data," *Proceedings of a Workshop on Coastal Sediment Transport*, Technical Report DEL-SG-15-78, Department of Civil Engineering, University of Delaware, Newark, Del., Dec. 1976, pp. 63-78.

Keywords: *Surf zones, Wave theory, Field data, State-of-the-art*

A brief review of the kinematics and dynamics of wave breaking and turbulence in surf zones is made. Energy dissipation in breakers is attributed to six factors: (a) turbulence with air entrainment, (b) formulation of large-scale vortices, (c) bottom friction, (d) cascade to higher frequencies, (e) percolation, and (f) work done to suspend and transport sediments. The characteristics of breaking wave energy spectra (kinetic) are also reviewed. The available field data are sparse. Author calls for many more surf zone studies which simultaneously measure wave height and velocity fields. Since turbulence studies have primarily progressed through experimental empirism, much more field data of turbulent and wave-induced velocities are needed.

337. THORNTON, E.B., "Review of Longshore Current Relationships and Data Base," *Proceedings of a Workshop on Coastal Sediment Transport*, Technical Report DEL-SG-15-78, University of Delaware, Newark, Del., Dec. 1976.

Keywords: *Longshore currents, Wave theory, State-of-the-art*

A brief review is made of the many formulas for longshore mean currents (as of 1976) with emphasis on the momentum flux approach using radiation stress theory. The many assumptions within the surf zone are discussed. Bottom shear stress and lateral shear stress empirical relationships are also reviewed briefly. The author also tabulates the laboratory and field data base sources and concludes that "...at this time (1976) there appears to be no single set of precise longshore current measurements in the field that have been under fairly ideal conditions in order to make a rigorous comparison with the available longshore current formulations." The author concludes that at present a reasonable theoretical framework exists to make time-averaged longshore current calculations. Deficiencies in applying the formulas are because: (a) The coefficients for bottom shear stress and lateral eddy diffusivity are not well defined. More experiments are needed to get more information about bottom shear stress coefficients. (b) Breaker type must be considered in the formulation for longshore current. This is due to the fact that spilling or plunging breakers, for example, give very different distributions of momentum flux across the surf zone. (c) The assumption of a constant sloping bottom must be relaxed to include more realistic bottom profiles including bars. The momentum flux technique breaks down when waves break on a bar and then re-form inside. The author feels mass transport must enter the formulation here. (d) More precise wave height and direction information is needed to verify existing theories and specify coefficients.

338. THORNTON, E.B., "Rederivation of the Saturation Range in the Frequency Spectrum of Wind-Generated Gravity Waves," *Journal of Physical Oceanography*, Vol. 7, No. 1, Jan. 1977, pp. 137-140.

Keywords: *Wave theory*

The saturation range in the frequency spectrum of wind-generated waves is rederived. Laboratory and theoretical work shows that wave breaking is the result of kinematic instability, suggesting that wave celerity is the governing parameter in the saturation range. Using similarity arguments, a general formulation is rederived giving the wave profile spectrum $S_\eta(\omega)\alpha_o^{-5}$ in deep water as derived by Phillips and $S_\eta(\omega)\alpha_o^{-3}$ in shallow water. The velocity spectrum in the saturation range is derived using linear wave theory as a spectral transfer function. In both deep and shallow water the horizontal velocity spectrum $S_u(\omega)\alpha_\omega^{-3}$. Wave and velocity measurements made in deep and shallow water are presented showing agreement with theory. (Author)

339. THORNTON, E.B., "Energetics of Breaking Waves Within the Surf Zone," *Journal of Geophysical Research*, Vol. 84, No. C8, Aug. 1979, pp. 4931-4938.

Keywords: *Surf zone, Wave breaking, Laboratory experiments, Velocity Turbulence*

Surface elevations and velocities were measured for a variety of breaking wave conditions including collapsing, plunging, and spilling breakers. Turbulent and wave-induced velocity components are separated by associating the wave-induced velocity components with contribution coherent with the surface. Most of the measurements were made in the lower half of the water column and are indicative of conditions in this region. The average velocity intensity for all experiments was 85 percent wave induced, indicating that the kinetic energy is primarily wave induced. Remarkably little difference was found between collapsing,

plunging, and spilling breakers in terms of percent wave-induced velocity intensity. (DHL)

340. THORNTON, E.B., "Longshore Currents and Bed Shear Stress," *Proceedings, Euromech 114* (Wave and Beach in Surf Zones), Polish Academy of Sciences, Jurata, Poland, Sept. 1980.

Keywords: *Longshore currents, Bottom shear, Wave theory, Field experiments*

Field measurements of the surf zone velocity and surface elevation fields have been made at Torrey Pines Beach, California, in 1978 as part of the Nearshore Sediment Transport Study. They are employed to compute the radiation stress Sxy, and hence its gradient alongshore which must be balanced by the average alongshore bottom shear stress for straight, parallel contour beaches. Using a quadratic form for the shear stress, the objective was to calculate the bed shear stress coefficient using direct field measurements. The calculated C_f values show considerable scatter across the surf zone and in time based on 17-minute averages for 1 day's measurements. The calculated C_f values occur outside the surf zone where some negative values mean the wave drove the current in the wrong direction. The average for this day's calculations(1 November 1980) is 0.006. A comparison of all days calculated indicated that the bed friction coefficient is consistently lower inside the surf zone.

341. THORNTON, E.B., and SCHAEFFER, G., "Probability Density Functions of Breaking Waves," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1979, pp. 507-519.

Keywords: *Surf zone, Wave breaking, Wave theory*

Waves in the surf zone are a highly nonlinear process which is evident by the appearance of secondary waves. The secondary waves appear as strong peaks in the period probability density functions corresponding to the first harmonic of the peak of the wave spectrum. The strong first harmonic period peak is also reflected in the highly correlated height and velocity probability density functions. Due to the high probability density functions for periods and heights of the breaking waves show high correlation (0.60 to 0.80) which indicates that greater wave periods are associated with large breaker heights. The joint probability density functions of period and particle velocity, and velocity and height, suggest that the maximum onshore particle velocities are correlated with both the wave periods and wave heights. (Authors)

342. THORNTON, E.B., and SMITH, R.M., "Breaking Wave Criterion on a Sloping Beach," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Wave breaking, Theory, Numerical simulation*

Theoretical, horizontal wave-induced velocity and wave speed are used to derive a breaking criterion. A perturbation technique is used to derive a second-order expression for the horizontal water particle velocity for long waves shoaling on a sloping beach. The hypothesis is that for the first instance that u equals c, i.e., the kinematic breaking criterion is used.

All other, closer in, points where this occurs are imaginary. The solution given is shown to produce results closer to experimentally obtained values.

343. THORNTON, E.B., et al., "Kinematics of Breaking Waves," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. I, 1976, pp. 461-476 (also Annual Report No. NPS-68TM 77071, Department of Oceanography, U.S. Naval Postgraduate School, Monterey, Calif., July 1977.

Keywords: *Field data, Wave velocities, Spectral analysis, Wave breaking, Field experiments, Particle velocities*

Measurements of waves, and vertical and horizontal water particle velocities were made of spilling, plunging, and surging breakers at sandy beaches in the vicinity of Monterey, California. The measured breaking waves, derived characteristically from swell-type waves, can be described as highly nonlinear. Spectra and cross spectra were calculated between waves and velocities. Secondary waves were noted visually and by the strong harmonics in the spectra. The strength of the harmonics is related to the beach steepness, wave height and period. The phase difference between waves and horizontal velocities indicates the unstable crest of the wave leads the velocities on the average by 5° to 20°. Phase measurements between wave gages in a line perpendicular to the shore show breaking waves to be frequency nondispersive indicating phase coupling of the various wave components. The coherence squared

values between the sea surface elevation and the horizontal water particle velocity were high in all runs, ranging above 0.8 at the peak of the spectra. The high coherence suggests that most of the motion in the body of breaking waves is wave induced and not turbulent. (Authors)

344. TSUCHIYA, Y., and SHIBANO, T., "Observations of Longshore Currents and Sand Drifting in Storm Conditions at Ogata Coast," *Coastal Engineering in Japan*, Tokyo, Japan, Vol. 16, Dec. 1973, pp. 93-106.

Keywords: *Longshore currents, Field observations, Japan*

Since there is a long pier, 250 meters offshore, at the Ogata coast a systematic observation of nearshore process can be carried out within the offshore range of about 250 meters from the shoreline. In this paper, some results of offshore distributions of longshore current and sand drifting in storm conditions are described with the characteristics of wind and incoming waves. (Authors)

345. TSUCHIYA, Y., YSUDA, T., and TOKUDA, K., "Theoretical Approach to Rip Current Problems," *Proceedings of the 26th Japanese Conference on Coastal Engineering*, Japan Society of Civil Engineers, 1979.

Keywords: *Rip currents, Wave theory, Mechanisms, Eigenvalues*

A theoretical investigation on the mechanism of rip current generation is developed. The mass transport due to wave action plays an essential role in the generation and maintenance of coastal currents. Based on this concept, mass transport term due to wave action is directly introduced into the basic equation set of nearshore current. The mass transport term is derived from the cnoidal wave theory and an appropriate approximation is given. The basic equation set is properly linearized and an approximate solution is obtained to the case of uniform beach attacked by normally incident waves.

The rip spacing is obtained as the eigenvalue of the equation set under the following two approximations. The first approximation is to eliminate the bottom friction and horizontal mixing terms, and the second approximation is to eliminate only horizontal mixing term. The calculations are performed by using different friction factors and the results are compared with laboratory and field data. (Authors)

346. UFFINK, A.C.M., "Energy Dissipation and Set-Up in the Surf Zone," Delft, Technical Hogeschool, Afd., Civiele Techniek, Vakgroep Vloeistofmechanica, deel A, 1978 (in Dutch).

Keywords: *Surf zone, Wave setup, Energy dissipation*

347. VAN DORN, W.G., "Set-Up and Run-Up in Shoaling Breakers," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 738-751.

Keywords: *Wave setup, Laboratory experiments, Wave theory*

This paper reports the results of a series of laboratory experiments with periodic waves breaking on uniformly sloping impermeable beaches with the object of distinguishing setup from dynamic shoreline motions due to partial reflection, the combination of which is normally referred to as runup. The principal findings are:

(a) The mean setup across the breaker zone was observed to be linear with mean slope proportional to the square of the bottom slope. The mean slope was independent of frequency over slopes of 0.04 or less, and increased with wave period over steeper slopes.

(b) The dynamic runup range was found to be proportional to the square of wave period times beach slope, in agreement with the equation of motion for a nearly frictionless block sliding on corresponding slopes under gravity.

(c) The total runup was poorly correlated with Hunt's empirical formula, nor could any reasonable deterministic justification of this formula be deduced from the present results.

(d) Transient runup was observed to considerably exceed steady-state values in most cases, suggesting that time-dependent momentum flux should be considered in the runup of variable (natural) waves.

(Author)

348. VISSER, P.J., "Longshore Current Flows in a Wave Basin," *Abstracts, Proceedings of the 17th International Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

Keywords: *Longshore currents, Laboratory experiments, Basin calibration*

An experimental investigation to determine the proper design of wave basins to simulate longshore currents generated by oblique waves on a plane(infinite) beach. The criterion for such models is a zero gradient

of the mean water level in the longshore direction and a uniform profile along the beach. Due to short model lengths and small wave amplitudes, some variation in setups is present and it becomes impossible to optimize the recirculation of water using measurements of mean water level. An alternative method is investigation in which waveguide, surf zone openings and a pump recirculates water under the waveguide board in the surf zone. The experiments vary the width of the downstream wave opening and the pump recirculation flow rate to empirically determine those values giving a minimum circulation flow rate beyond the breakers near the wave paddle.

349. VOS, R.G., "Observations on the Formation and Location of Transient Rip Currents," *Sedimentary Geology*, Amsterdam, The Netherlands, Vol. 16, No. 1, July 1976, pp. 15-19.

Keywords: *Rip currents, Theoretical model, Transients*

A model for the formation and location of transient rip currents is proposed. It is suggested that sucking and erosion effects at the peak site (highest part) of a set of large breaking waves initiate seaward current in a scoured breaker zone at the same time that water is accumulating inside the breakers. Accumulated water inside the breakers immediately begins to drain seaward through the peak site, feeding this embryonic rip current, which develops into a mature rip current. Rip-current formation in this manner best occurs following storms when a moderate swell, negligible or offshore winds and a flat shoreface profile are present. (Author)

350. VREUGDENHIL, C.B., "A Method of Computation for Unsteady Wave-Driven Coastal Currents," Report No. 1174, Pt. 1, Delft Hydraulic Laboratory, Delft, The Netherlands, Aug. 1980.

Keywords: *Nearshore circulation, Numerical simulation*

A description is presented for the numerical method of computation for unsteady coastal currents and circulation patterns as devised by the Delft Hydraulic Laboratory. The unsteady case is of interest to study moving rip currents generated by instability of the longshore current and wave field. The equations are those for time-averaged, long waves in shallow water, extended with radiation stresses as driving forces and utilize an empirical eddy-viscosity coefficient and formulation for lateral stresses. The wave field and subsequent radiation stresses are determined by means of linear wave theory. Bottom friction is assumed linearly proportional to the mean current. Wave breaking is empirically treated as a constant proportion between wave height and wave depth throughout the surf zone. Considerable discussion of appropriate boundary conditions near groin fields is presented. An implicit, finite-difference algorithm is the solution procedure on a transformed, rectangular grid to simplify solution over irregular boundaries. The author also includes a detailed discussion of numerical viscosity resulting from truncation errors of the convective acceleration terms.

351. WALTON, T.L., Jr., "Computation of Longshore Energy Flux Using LEO Current Observations," CETA 80-3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Mar. 1980.

Keywords: *Longshore current, Wave theory*

A computational technique is presented for the longshore energy flux factor, P_{ls}, using current observations from the Littoral Environment Observation (LEO) program. Chapter 4 of the Shore Protection Manual (SPM) gives various equations for P_{ls} as a function of wave height, wave period, and breaking wave angle. The present report details how P_{ls} can be calculated using longshore current and breaking wave height data only. (Author)

352. WEISHAR, L.L., and BYRNE, R.J., "Field Study of Breaking Wave Characteristics," *Proceedings of the 16th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1978, pp. 487-506.

Keywords: *Wave breaking, Field experiments, Wave theory*

This study focuses upon four elements of breaking wave behavior:

(a) Relative breaking depth criteria.
(b) Breaking wave classification.
(c) Evaluation of the plunge distance.
(d) Breaking wave height prediction.

The data set is 116 waves filmed at Virginia Beach, Virginia, on the Atlantic coast. The cine-photographic observation technique permitted the viewer to freeze the free surface profile at successive time steps as the waves passed an upright plane grid placed perpendicular to the beach. The results indicate that:

(a) While the average value of $H_b/d_b = 0.78$, there was a significant

difference between plunging and nonplunging waves.

(b) Neither the breaker classification of Galvin nor that of Battjes successfully discriminated between plunging and spilling breakers.

(c) The distance traveled by the foreface of a plunging wave was found to be underestimated by the free-fall trajectory model advanced by Galvin. The field observations show the weakness to be in the plunge time arising from neglect of the vertical velocity component.

(d) The breaking wave height prediction formulation advanced by Komar and Gaughan adequately predicts the breaking wave height within the constraints of calculating deepwater wave characteristics, neglecting wave refraction and frictional effects. The combined data set covers the breaker wave height between laboratory scale observations to greater than 3 meters.

(Authors)

353. WHEELER, W.H., *The Sea Coast*, Longmans, Green and Co., London, 1902.

Keywords: *Field observations, Design considerations, England*

Chapter II - The Action of Shore Waves - gives very limited but accurate of how waves behave and break on shorelines.

p. 13 "The mean level of the sea at the place where a wave breaks on the shore...is...increased by the impetus of the waves. Hence the surface of the water forms a slope upwards towards the shore, causing an undercurrent towards the sea, which has considerable effect in pulling beaches down and conveying material seaward."

There is also a discussion of littoral drift.

354. WIEGEL, R.L., "Fluid Mechanics of the Nearshore Zone," *Proceedings of the Sixth Australasian Hydraulics and Fluid Mechanics Conference*, 1977, pp. 145-154.

Keywords: *State-of-the-art, Nearshore zone, Coastal currents, Tidal currents, Surf zone currents*

Author defines and discusses currents in the nearshore zone. Three classes of currents are reviewed, namely: coastal currents, tidal currents, and longshore currents in the surf zone. It is noted that few of the many papers on longshore currents present data on measurements in the surf zone and there are almost no data on wind-generated (offshore) waves and currents. Also recent measurements in Japan by tethered balloons of circulation cells in the surf zone (i.e., longshore and rip currents) differ significantly from theoretically predicted nearshore circulation patterns. Much more research is called for including incorporation of the movable bottom in the theory.

355. WIEGEL, R.L., PATRICK, D.A., and KIMBERLEY, H.L., "Wave, Longshore Current, and Beach Profile Records for Santa Margarita River Beach, Oceanside, California," *American Geophysical Union*, Vol. 35, No. 6, Dec. 1954, pp. 887-896.

Keywords: *Longshore currents, Field experiments*

The results of 10 months of measurements of waves, longshore currents, and beach conditions for Santa Margarita Beach are presented. Tables and graphs give the height, period, and steepness of the incident waves as measured by a subsurface differential-type pressure recorder; breaker heights as computed from these data; observed wave directions; longshore current measurements, both mangitude and direction, as obtained by tracing dye thrown into the water; and beach profiles measured along three ranges 500 feet apart from the berm to a depth of about 25 feet. It was found that the three sets of profiles were not consistent in regard to their relationship with varying wave conditions and further that the type of beach profile (storm or ordinary) apparently did not bear the same relationship to the wave steepness as has been found in laboratory studies. (Authors)

356. WINANT, C. D., "Internal Surges in Coastal Waters," *Journal of Geophysical Research*, Vol. 79, No. 30, Oct. 1974, pp. 4523-4526.

Keywords: *Surf zone, Wave theory, Fluid density, Temperature*

A multiple element thermistor chain was installed at the end of Scripps pier in LaJolla, California, in 5 meters of water along with a pressure sensor to record sea-surface fluctuations. Temperature fluctuations throughout the water column are characterized by the occurrence of events, times during which a significant thermal gradient, of the order of or greater than those associated with the seasonal thermocline in deeper waters, exists in the water column. Temperature differences between the bottom and the surface of up to 5° Celsius have been measured in events that are similar to those reported by Cairns (1967). The contributions of this work are to report (a) that the onset can be very rapid, occurring during times of the order of 1 second, (b) that motions exist in the water column at frequencies that are much higher than the buoyancy frequency but are not directly coupled to the surface wave

field, and finally (c) that events are likely to be strongly three dimensional in such shallow waters. Extrapolations of observations at Scripps pier on a worldwide scale indicate that such events could be responsible for an energy flux into shoal waters ranging between 2×10^5 kW and 2×10^7 kW, an estimate which is to be compared with the 2.5×10^6 kW proposed by Wunsch and Hendry (1972) on the basis of estimates of the power in the form of internal waves, incident on the coastline of the world. (Author)

357. WINANT, C.D., "Velocity Measurement," *Proceedings of the Nearshore Sediment Transport Study Workshop on Instrumentation for Nearshore Processes*, Scripps Institution of Oceanography, 1977, pp. 44-52.

Keywords: *Surf zone, Velocities, Instrumentation*

Only those current meters which independently sense two orthogonal components of the velocity vector and have a linear response to velocity and a cosine response to the angle between the velocity vector and the orientation of each axis sensed are discussed. One advantage of these current meters is their ability to average properly current fluctuations at frequencies higher than those being sampled--simplicity in data reduction and calibration. Advantages and disadvantages of three types of sensors (acoustic traveltime, electromagnetic, and mechanical sensors), are discussed.

358. WIND, H.G., "Some Aspects of the Component of Radiation Stress S(xx) and Set-Up on Gentle Slopes," *Euromech 102* (Breaking Waves: Surf and Run-Up on Beaches), University of Bristol, Bristol, England, July 1978.

Keywords: *Wave setup, Wave thrust (radiation stress), Theoretical model*

In this note four aspects of the radiation stress S(xx) and the setup are analyzed: linear wave approximations in the setup calculation; the potential energy density at the breakpoint calculated from the observed variations of the water surface; the radiation stress S(xx) calculated from the integration of the mean water level from the shore toward deep water; and a velocity integral calculated from observed results. A comparison of these aspects with the linear wave theory will be made, the first part of this note contains some formulas required for further analyses and the presentation of the experiments. (DHL)

359. WIND, H.G., "Breaking Waves: Characteristics of Shoaling and Breaking of Periodic Waves Normally Incident to Concrete Beaches of Constant Slope," Report M.1371, Delft Hydraulic Laboratory, Delft, Netherlands, Aug. 1979.

Keywords: *Wave breaking, Laboratory studies*

Laboratory investigations of breaking waves on beach were made for the Rijksuaterstaat. Regular waves were used on a series of beaches of constant slopes. The main variables were wave characteristics and beach slope. Wave heights, root mean square and mean modulus of w.s. elevation fluctuation, setup and setdown (pressure taps) wave celerity, water depths in wave at various points along the flume, breaker point, plunge point, end of aeration runup, rundown, etc. Results presented in form of graphs and compared with published literature. Particularly that of Bowen for setdown.

360. WOOD, W.L., "A Wave and Current Investigation in the Nearshore Zone," Contract N00014-68-A-0109-0002, Purdue University, Department of Geosciences, Lafayette, Ind., June 1973.

Keywords: *Surf zone, Velocity fields, Field studies, Wave theory*

The report is the final report on wave and current investigations in the nearshore zone. A spatial resolution method has been developed for determining wavelengths in the surf. This system prevents the error introduced due to rapidly transforming waves which arises in conventional calculated wavelength determinations. Subsurface photographic studies on particle velocities in breaking waves have indicated both horizontally dominant and vertically dominant flow paths beneath the crests of breaking waves. Breaker height decay analysis has shown that turbulence due to breaking dominates bottom friction in the nearshore zone. Likewise a prediction equation is generated which will predict the exponential decay of wave height as a function of distance shoreward from the breakpoint . A complete wave shape classification system has been developed for evaluating stability and energetics of the surf zone. This system is used in conjunction with a two-dimensional time projection of the free surface to evaluate nearshore surface wave behavior. (Author)

361. WOOD, W.L., "Three-Dimensional Conditions of Surf," *Proceedings of the 15th Conference on Coastal Engineering*, American Society of Civil Engineers, Vol. 1, 1976, pp. 525-538.

Keywords: *Longshore and nearshore currents, Wave theory, Variability, Field studies*

Wave height variability along the crest of breaking waves is shown to be a significant factor in the assessment of surf zone dynamics. Variations in excess of 50 percent of the maximum wave height can occur along a single crest without significant variations in bathymetry. The horizontal scale of this longshore variability in crest height corresponds to the wavelength of incident breaking waves. Four possible mechanisms for this variability are postulated and then evaluated individually on the basis of field observations. A major result of these evaluations is that two-dimensional shallow-water wave equations appear to be inappropriate for expressing natural surf zone wave transformations and water motions even under the condition of waves encroaching on a plane sloping bottom. Consequently, three-dimensional equations of surf should be used for describing most natural surf zone dynamics.

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362. WOOD, W.L., and MEADOWS, G.A., "Unsteadiness in Longshore Currents," *Geophysical Research Letters*, Vol. 2, No. 11, 1975, pp. 503-505.

Keywords: *Longshore currents, Field experiments, Time variations*

Classically, field and laboratory investigations have relied on averaged results from Lagrangian measurements to establish longshore current velocities. Likewise, conservation equations have been time average in the formulation of longshore current theories. Recent experimental measurements by the authors indicate that at a fixed point in the surf zone variations in excess of 150 percent of the mean current velocity occur over time periods from 3 to 80 seconds. These unsteady motions in longshore currents, persist horizontally across the surf zone and vertically from the surface to the bottom. This persistence and magnitude of the observed velocity fluctuations from this investigation imply that time dependent analytic treatments of conservation equations are necessary to properly determine longshore current velocity. (Authors)

363. WOODWARD, W., MOORS, C.N.K., and JENSEN, K., eds., *Proceedings of a Working Conference on Current Measurement*, Technical Report DEL-SG-3-78, National Oceanic and Atmospheric Administration and University of Delaware, Newark, Del., June 1978.

Keywords: *Current measurements*

The Office of Ocean Engineering of NOAA sponsored a 3-day conference (January 1978) to provide a focus for technical information exchange among those in the marine community involved in current measurement and in defining and promoting realistic initiatives directed toward improving the national current measurement capability. No papers directly concerned with surf zone current measurement. However, the paper by McCullough on current measurements near surface with waves present discusses problem and performance of rotor-type meters.

364. WRIGHT, L.D., et al., "Field Observations of Resonant Surf and Current Spectra on a Reflective Beach and Relationships to Cusps," *Search*, Vol. 8, Sept. 1977, pp. 321-322.

Keywords: *Resonant beaches, Standing waves, Edge waves*

Inshore wave and current behavior measured in the field at a pocket beach (Bracken Beach, South Coast, Australia) to study dissipative and reflective beach systems. The beach was classified as reflective (resonant) using the beach reflectivity parameter (Guza and Bowen, 1975) and phase relationships between current and water surface elevations. Such resonant beaches are characterized by standing waves which in this example proved to be trapped mode edge waves. Beach cusps are associated with such beaches.

365. WRIGHT, L.D., et al., "Morphodynamics of Reflective and Dissipative Beach and Inshore Systems: Southeastern Australia," *Marine Geology*, Amsterdam, The Netherlands, Vol. 32, No. 1/2, June 1979, pp. 105-140.

Keywords: *Surf zone, Nearshore circulations, Field experiments, Currents*

Field experiments involving direct measurement of surf and inshore

current spectra, inshore circulation patterns, and depositional morphology have been replicated under different energy conditions and in several environmentally contrasting beach localities on the high-energy coast of New South Wales, Australia. The region exhibits compartmentalized beach systems and is dominated by a highly variable wind-wave climate superimposed on persistent high-energy swell (T = 10-14 seconds). Two general types of beach system occur: (a) predominantly reflective systems in which much of the incident wave energies are reflected from the beach face; and (b) dissipative systems with wide surf zones and high turbulent energy dissipation.

Reflective systems are characterized by steep, linear beach faces, well-developed berms and beach cusps, and surging breakers with high runup and minimum setup; rip cells and associated three-dimensional inshore topography are absent. Wave height and current spectra from reflective beaches consistently have their dominant peaks at incident wave and subharmonic frequencies, and cross-spectra indicate the existence of low-mode edge waves at those frequencies. Infragravity peaks are negligible. Under low-energy conditions subharmonic peaks are low relative to incident wave peaks; however, increasing breaker height tends to be accompanied by increasing subharmonic dominance. Analysis of shore-normal currents near the bed show that under all conditions the strongest shoreward motions are induced by the incident waves; however, seaward motion near the beach face is subharmonic-dominated.

Dissipative systems characterize the exposed open coast and are fronted by concave-upward nearshore (seaward or break) profiles and wide flat surf zones. Waves break 75 to 300 meters seaward of the beach and dissipate much of their energy before reaching the beach, creating significant radiation-stress gradients and setup.

366. ZENKOVICH, V.P., "Flourescent Substances as Tracers for Studying the Movement of Sand on the Sea Bed: Experiments Conducted in the U.S.S.R.," *Dock and Harbour Authority*, London, England, No. 40, Jan. 1960, pp. 280-283.

Keywords: *Longshore currents, Field experiments, Sediment transport*

As discussed in Thornton (1969), this early field study of littoral drift also included sketches of longshore current distribution across the surf zone. The maximum current reported was about 0.6 meter per second at the bars.

367. ZENKOVICH, V.P., *Processes of Coastal Development*, J.A. Steers and C.A.M. King, eds., (1967 (translated from Russian by D.G. Fry, Oliver, and Boyd Publishing Company, London; original Russian version, 1962).

Keywords: *Longshore currents, Nearshore circulation, Three-dimensional currents, State-of-the-art*

Chapter 6 discusses and summarizes the author's and other research efforts in coastal currents up to about 1960. It presents a good review of Russian thinking up to this time. Formulas for mean, longshore current magnitudes are presented. The author argues for three-dimensional structures in the nearshore zone and the presence of a bottom return flow on most coasts that results in unstable, complicated circulation patterns with a horizontal axis. Less stable circulations with a vertical axis procedure, rip currents, and gradient currents. No general picture of coastal hydrodynamics is said to be possible due to the diversity and complexity of the boundary conditions and instabilities involved. The author concludes by stating that the asymmetry of distorted waves on the coast is the most important factor and leads to wave breaking and dissipation.

APPENDIX A

SUBJECT INDEX

APPENDIX B

SOURCES OF INFORMATION

Journals

Journal of Hydraulic Research
Journal of Geophysical Research
Journal of Sedimentary Petrology
Journal of Marine Research
Journal of Mathematics & Mechanics
Marine Geology
Oceanus
Journal of Physical Oceanography
Journal of Waterway, Port, Coastal & Ocean Engineering
Nature
Journal of Fluid Mechanics
Oceanology, Academy of Sciences of the USSR
Surfers Almanac
Reviews of Geophysics and Space Physics
Coastal Engineering in Japan
Geophysical Fluid Dynamics
Journal of Geological Society of London
Journal of Oceanographic Society of London
Journal of Oceanographic Society of Japan
Estuarine & Coastal Marine Science
Canadian Journal of Earth Science
Shore and Beach
Coastal Engineering
Indian Journal of Marine Sciences
Dock and Harbor Authority Journal
Ann. Hydrogr.
Bulletin of the Geological Society of America
Transactions of the American Geophysical Union
IEEE Transactions Microwave Theory & Technique
Proceedings of the Royal Society of London
The Geographical Journal (London)
Journal of Geology
Atmospheric & Oceanic Physics (USSR)
Transactions of the Japanese Society of Civil Engineering
Limnology & Oceanography
Photogrammetric Engineering
Sedimentary Geology
Geophysics Research Letters

Conference Proceedings

Proceedings, Coastal Engineering Conference (1980, 78, 76, 74, 72, 70, 68, 66, 64, 62, 51, 50)
Proceedings, Euromech 102, 1978
Proceedings, Symposium on Modeling Techniques, ASCE, 1975
Proceedings, International Assoc. of Hydraulic Research, 1979, 1963
Proceedings, Australian Conference on Coastal and Ocean Engineering (1978, 77, 75, 73)

Conference Proceedings (continued)

Proceedings, Symposium on Coastal Sediments, ASCE, 1977
Proceedings, Eleventh Pacific Science Congress, 1968
Proceedings, Coastal Engineering Conferences in Japan, 1979, 1968
Proceedings, Oceans Institute of Electrical and Electronics Engrs, 1979
Proceedings, Water Resources Engineering, Annual Meeting, ASCE, 1969
Proceedings, 2nd Tech. Conf. on Hurricanes, 1962
Proceedings, Civil Engineering in the Oceans, 1975
Proceedings, Int'l Symposium on Ocean Wave Measurement, ASCE, 1974
Proceedings, Fifth Int'l Conference on Port and Ocean Engineering Under Arctic Conditions, 1979, 1978
Proceedings, Workshop on Coastal Sediment Transport, Delaware, 1978
Proceedings, South African Council for Scientific and Industrial Research, 1969, 1962, 1961
Proceedings, Nearshore Sediment Transport Study Workshop on Instrumentation for Nearshore Processes, Scripps, 1977
Proceedings, 15th Conf. on Great Lakes Research, 1972
Proceedings, Water Resources and Ocean Engineering, National Mtg., ASCE, 1976
Proceedings, Int'l Conf. on Applied Numerical Modeling, Southampton, 1977
Proceedings, 13th Int'l Congress of Theoretical & Applied Mechanics, 1972
Proceedings, Int'l Conf. on Behavior of Off-Shore Structures, BOSS, 1976
Proceedings, Symposium on Technical, Environmental, Socioeconomic and Regulatory Aspects of Coastal Zone Management, ASCE, 1978
Proceedings, Int'l Investigations Lubiatowo - 1976 (Poland) in Hydrotechnical Transactions, Vol. 41, 1980
Proceedings, Annual Contractors Conference, Coastal Geography Programs, 1976
Proceedings, SPEM Research Symposium, 1975
Proceedings, Coastal Structures 79, ASCE, 1979
Proceedings, Nearshore Sediment Transport Study Workshop on Instrumentation for Nearshore Processes, Scripps, 1977
Proceedings, Tenth Int'l Liege Colloquim on Ocean Hydrodynamics, 1978
Proceedings, 2nd Nat'l Coastal and Shallow Water Research Conf., 1971
Proceedings, Sixth Australasian Hydraulics and Fluid Mechanics Conference, 1977

Government, University and Consulting Reports (Theses & Dissertations)

Franzius-Institute fur Grund-und Wasserbau, Hanover (West Germany)
Corps, Coastal Engineering Research Center
Rijkswaterstaat, Dept. of Coastal Research (The Netherlands)
Delft Univ. of Technology, Dept. of Civil Engr. (The Netherlands)
University of Delaware, Ocean Engr. Dept., Newark
University of California, San Diego, Scripps Inst. of Oceanography
Queen's University, Civil Engr. Dept. (Ontario, Canada)
U.S. Naval Postgraduate School, Monterey
University of Hawaii, Manoa Campus
Technical University of Denmark, ISVA, Lyngby (Denmark)
Florida State University, Tallahassee

Government, University and Consulting Reports (continued)

Leichtweiss-Institute fur Wasserbau, Braunschweig (West Germany)
University of Florida, Gainsville
Tetra Tech, Inc., Pasadena
University of Delaware, Dept. of Civil Engineering, Newark
Massachusetts Inst. of Technology, Hydrodynamics Lab, Cambridge
Williams College, Williamstown, Mass.
University of Queensland, St. Lucia (Australia)
University of Natal, Durban (S. Africa)
ESSA Research Laboratory, Norfolk
University of Bristol, Bristol (England)
Memoirs, Faculty of Engineering, Kyoto University, Kyoto (Japan)
University of Cambridge, Cambridge (England)
Oregon State University, Dept. of Oceanography, Corvallis
Purdue University, Lafayette
U.S. Navy, Coastal Geography Programs, Washington, D.C.
California Institute of Technology, Pasadena
University of Tokyo, Dept. of Civil Engineering, (Japan)
U.S. Goddard Space Flight Center, Greebelt, Md.
Virginia Institute of Marine Science, Glochester Point, Va.
Delft Hydraulic Laboratory, Delft (The Netherlands)

Basco, David R.
Surf zone currents. Volume II. Annotated bibliography / by David R. Basco and Rod A. Coleman.--Fort Belvoir, Va. : U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Springfield, Va. : available from NTIS, 1982.
[93] p. ; ill. ; 28 cm.--(Miscellaneous report--U.S. Coastal Engineering Research Center ; no. 82-7, v.II) (Contract DACW72-80-C-0003).
Prepared by Department of Civil Engineering, Texas A&M University.
Report provides a state-of-the art summary of research on coastal hydrodynamics and its three main components: longshore currents, nearshore circulations, and rip currents. Concentration is on all theoretical aspects since 1967 but earlier data are included.
1. Hydrodynamics--bibliography. 2. Longshore currents--bibliography. 3. Nearshore circulations--bibliography. 4. Numerical models--bibliography. 5. Rip currents--bibliography. 6. Surf zone currents--bibliography. I. Title. II. Coleman, Rod A. III. Texas A&M University. Department of Civil Engineering. IV. Series: Miscellaneous report (Coastal Engineering Research Center (U.S.)); no. 82-7, v.II.
TC203 .U58lmr no. 82-7, v.II 627

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TC203 .U58lmr no. 82-7, v.II 627